SAE Journal

SEPTEMBER 1956

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THE SKY IS THE LIMIT on aviation until we get an adequate national control system 18

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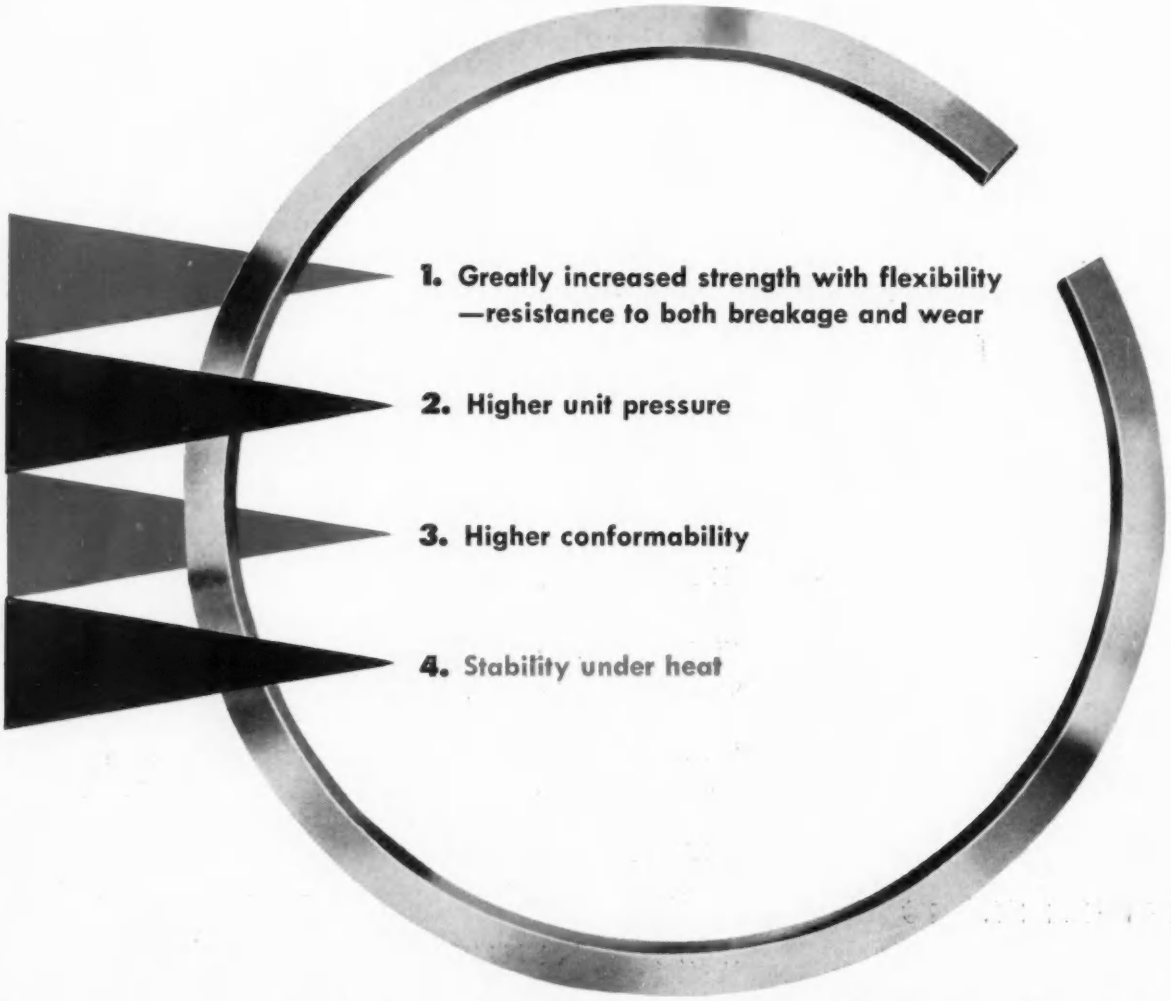
STEEL + CHROME

add up to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You get all these qualities demanded by modern high-compression and heavy-duty engines when you specify PERFECT CIRCLE chrome-plated STEEL compression rings... pioneered and perfected by Perfect Circle. Perfect Circle Corporation, Hagerstown, Indiana; The Perfect Circle Co., Ltd., Don Mills, Ontario.

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FACTS

about

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BALL BEARINGS

Split Inner Ring Main Shaft Ball Bearing

FOR AIRCRAFT TURBINES

High speeds, high temperatures and heavy loads . . . both radial and thrust . . . characterize bearing applications for turbines used in present ultra-fast aircraft.

New Departure's Aircraft Bearing Research Program has produced ball bearings for highly satisfactory operation in small, medium and large turbines and their accessories.

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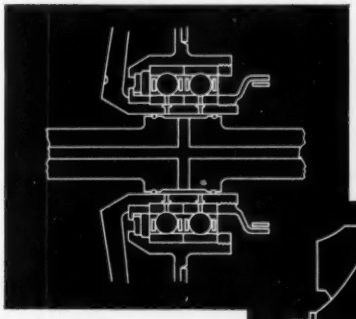
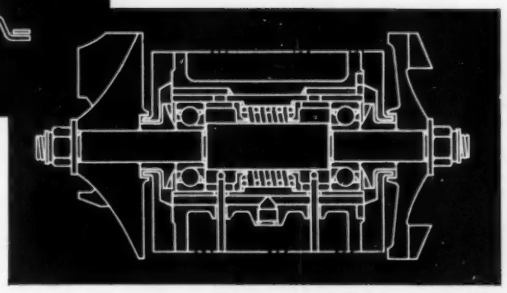
Beyond this, New Departure is working on bearing developments for the more powerful, faster aircraft of tomorrow.

For further details, send for Folder TB, on turbine bearings.

Accessory Ball Bearings



LEFT: Split Inner Ring Bearings on Turbine Main Shaft



RIGHT: Typical Installation of Ball Bearings in a Refrigeration Turbine

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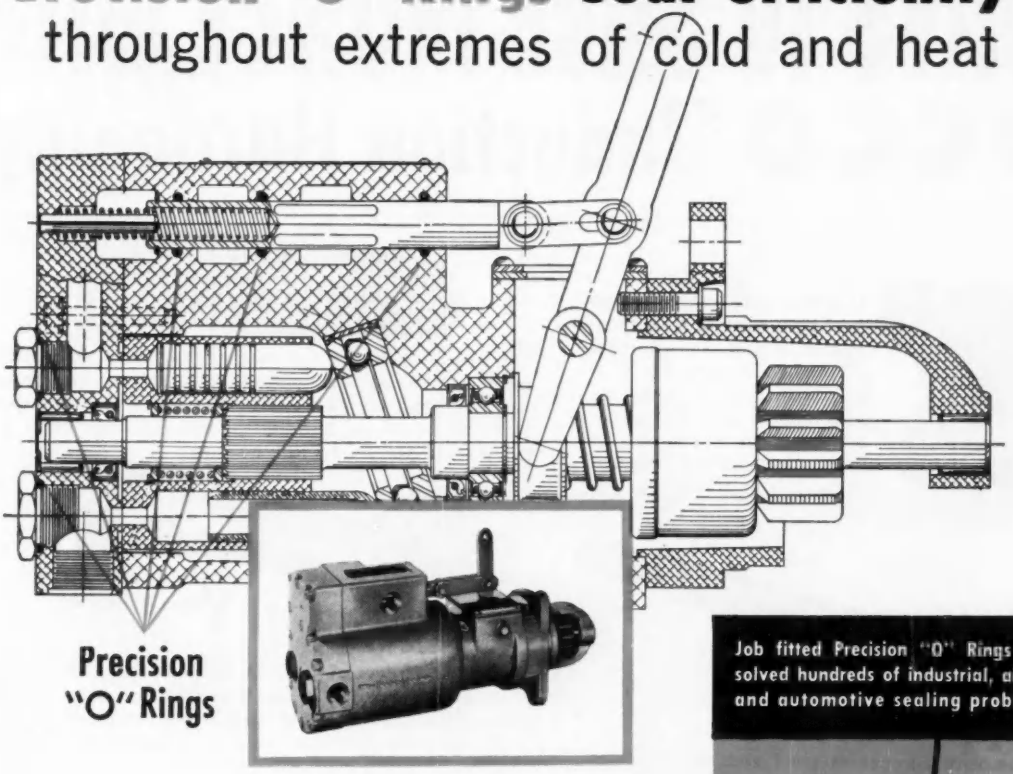
SAE JOURNAL, September, 1956, Vol. 64, No. 10. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office, at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 29 West 39th Street, New York 18, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster, Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1948. Additional entry at New York, N. Y.

Precision "O" Rings **seal efficiently** throughout extremes of cold and heat



The Hydrotor Hydraulic Cranking Motor, manufactured by Hydramotive, Inc., Cleveland, Ohio, provides high cranking torque and adjustable speeds over a temperature range of −65° to +165° F.

Hydramotive, Inc., standardized on Precision "O" Rings after exhaustive competitive tests. Precision "O" Rings guaranteed long life sealing and flexibility in arctic cold.

Precision "O" Rings are compression molded from quality controlled compounds. They're the finest made! Rigid inspection and engineering skill assure long life, leak proof sealing. Precision can furnish the size and compound that fits your requirements and "O" rings that meet all military and commercial specifications.

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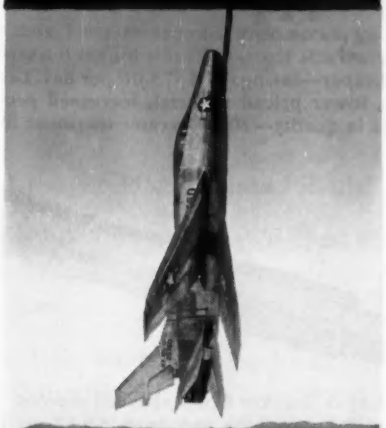
Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.



Precision "O" Rings meet military specifications and were used in the North American F-100C Super Sabre.

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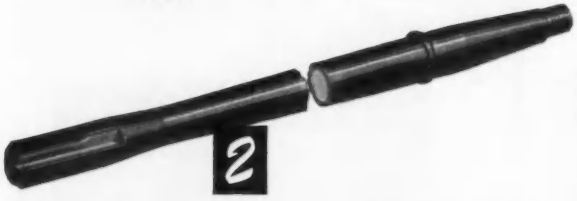
7 WAYS to SAVE MONEY with TOCCO* Induction Hardening

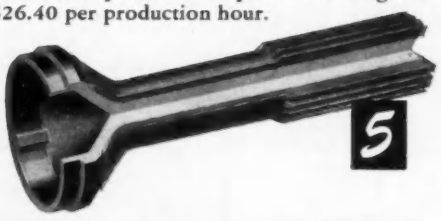
Cost was reduced 94% when heat-treatment of this corn-harvester part was changed from carburizing to TOCCO-hardening, 9½c saved on every piece — $4750 on each 50,000 piece batch, plus an hourly production increase from 120 to 300 pieces per hour.



Leading automotive companies need and use TOCCO hardened axle shafts to handle higher horsepower. Better, yet cheaper—savings of $375.00 per day. Less machining costs, lower priced material, increased production, and a plus in quality—200% greater torsional life.

Kearney & Trecker Corp. reduced the cost of hardening this milling machine part from $1.57 to 10c apiece. In addition TOCCO made possible a switch from alloy to S.A.E. 1045 steel—saving another 11c per piece in material cost. Kearney & Trecker hardens 140 different parts on one TOCCO unit.

Thompson Products Ltd. boosted production of these automotive wrist pins from 500 to 1200 per hour when they switched to TOCCO-hardening. Costs fell from $5.45 to $3.25 per hundred parts—a savings of 2c per pin, $26.40 per production hour.



Mechanics Universal Joint Division of Borg-Warner reports a 69% savings in the hardening of stub ends for propeller shafts. TOCCO also upped production from 35 to 112 parts per hour—over three times as fast as conventional heating methods.

Lima-Hamilton Corporation adopted TOCCO for hardening this shifting lever. Results: a savings of 4c per piece—$25 per production hour. TOCCO costs only 17% of former heating method. This is only 1 of 139 parts TOCCO-hardened by Lima-Hamilton Corp. All show savings over usual heating methods.

7 Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for similar cost-saving results—without obligation, of course.

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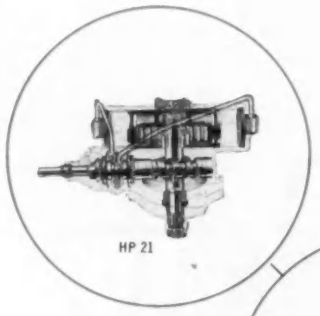
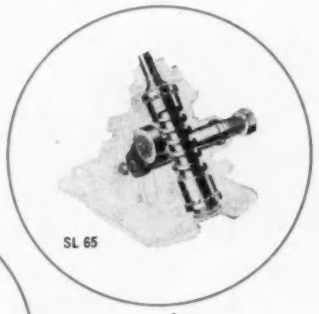
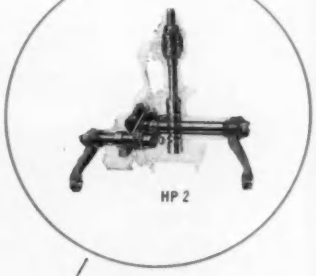
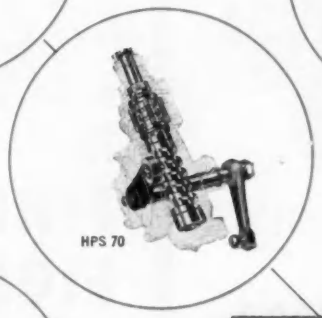
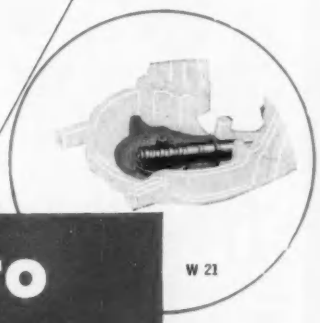
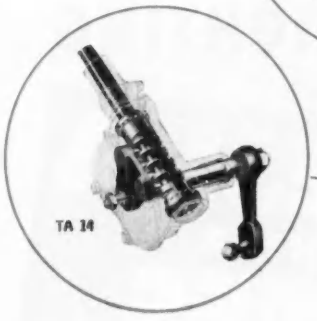




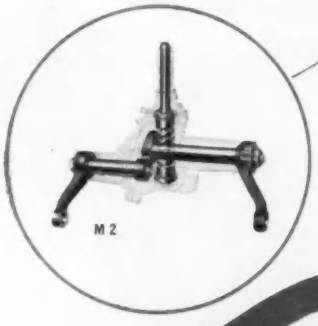








7 WAYS TO BETTER FARM* STEERING . . .



▶ **Farm** vehicles travel the world's roughest "roads". . .

That's why Ross spares no effort to provide the right steering gear for all farm equipment—tractors, combines and other agricultural machinery.

Pictured above are *seven* Ross models, manual and power, that are currently in production for *farm* equipment use. Four of these are entirely *new* gears which Ross has recently developed.

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...Waukesha Engines—*first* in fire fighting—the preferred power for the finest equipment, because specially built for *faster* fire fighting, they are reliable all the way. *Waukesha Motor Company, Waukesha, Wisconsin, New York, Tulsa, Los Angeles.*

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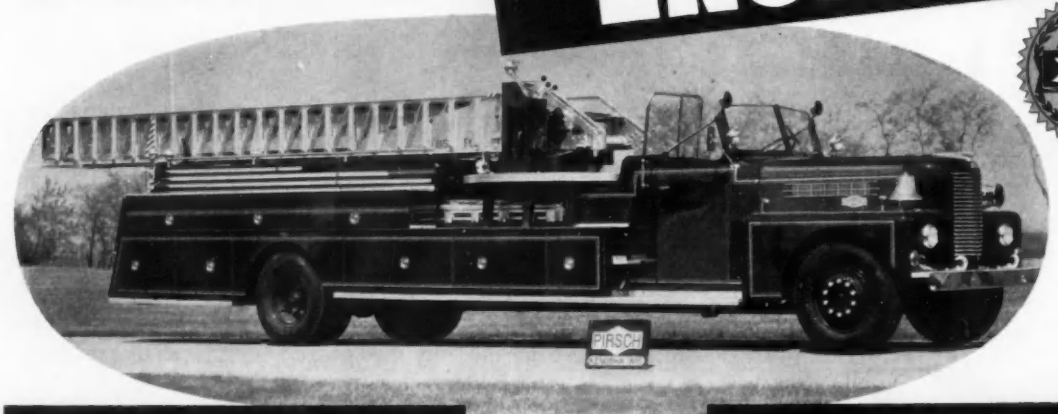
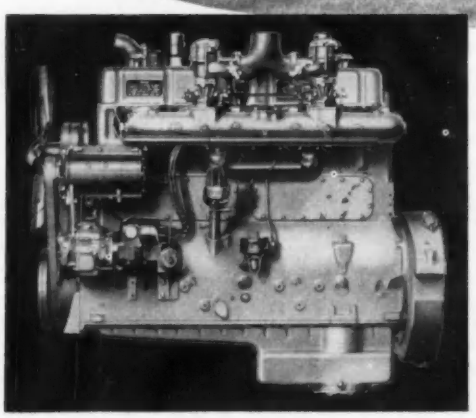
WAUKESHA FIRE FIGHTER ENGINES

50th ANNIVERSARY Waukesha MOTOR CO. 1906-1956





WAUKESHA FIRE FIGHTER ENGINES

Counterbalanced or Non-Counterbalanced

Typical 145 Series 779 or 817 cu. in., up to 275 hp.

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Send for Bulletins

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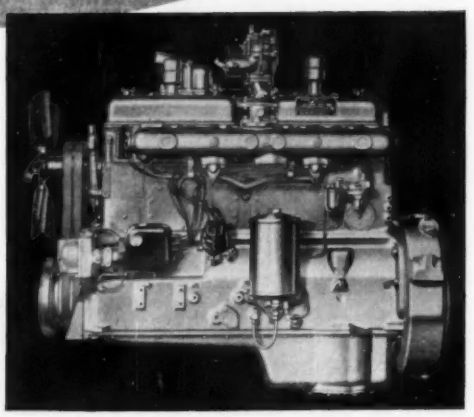

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AP 265/46

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who bothered to keep bulky seating down?

But what to do when high style gets lower and lower?

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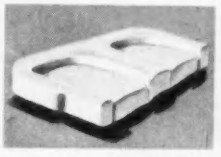
AIRFOAM makes interiors roomier, more luxurious



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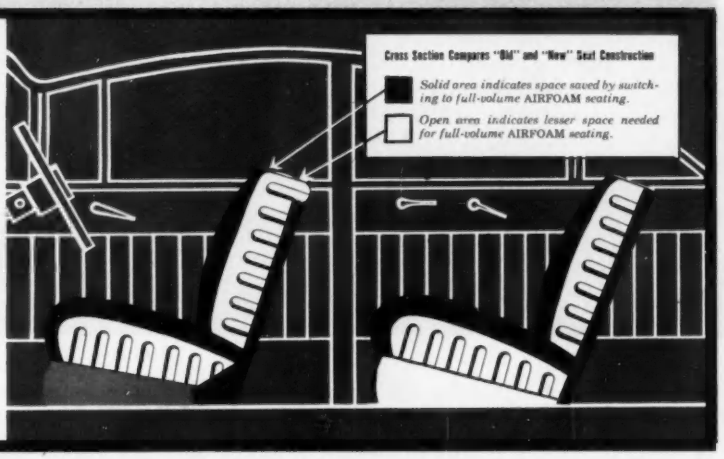

Cross Section Compares "Old" and "New" Seat Construction
Solid area indicates space saved by switching to full-volume AIRFOAM seating.
Open area indicates lesser space needed for full-volume AIRFOAM seating.

Exciting new seating ideas become *practical* with **AIRFOAM**

AIRFOAM can be your greatest sales-aid in years

TO KEEP UP WITH EXTERIOR DESIGN, interiors must really keep *down* to it. This presents king-size problems when designers are stuck with outdated upholstering methods and materials.

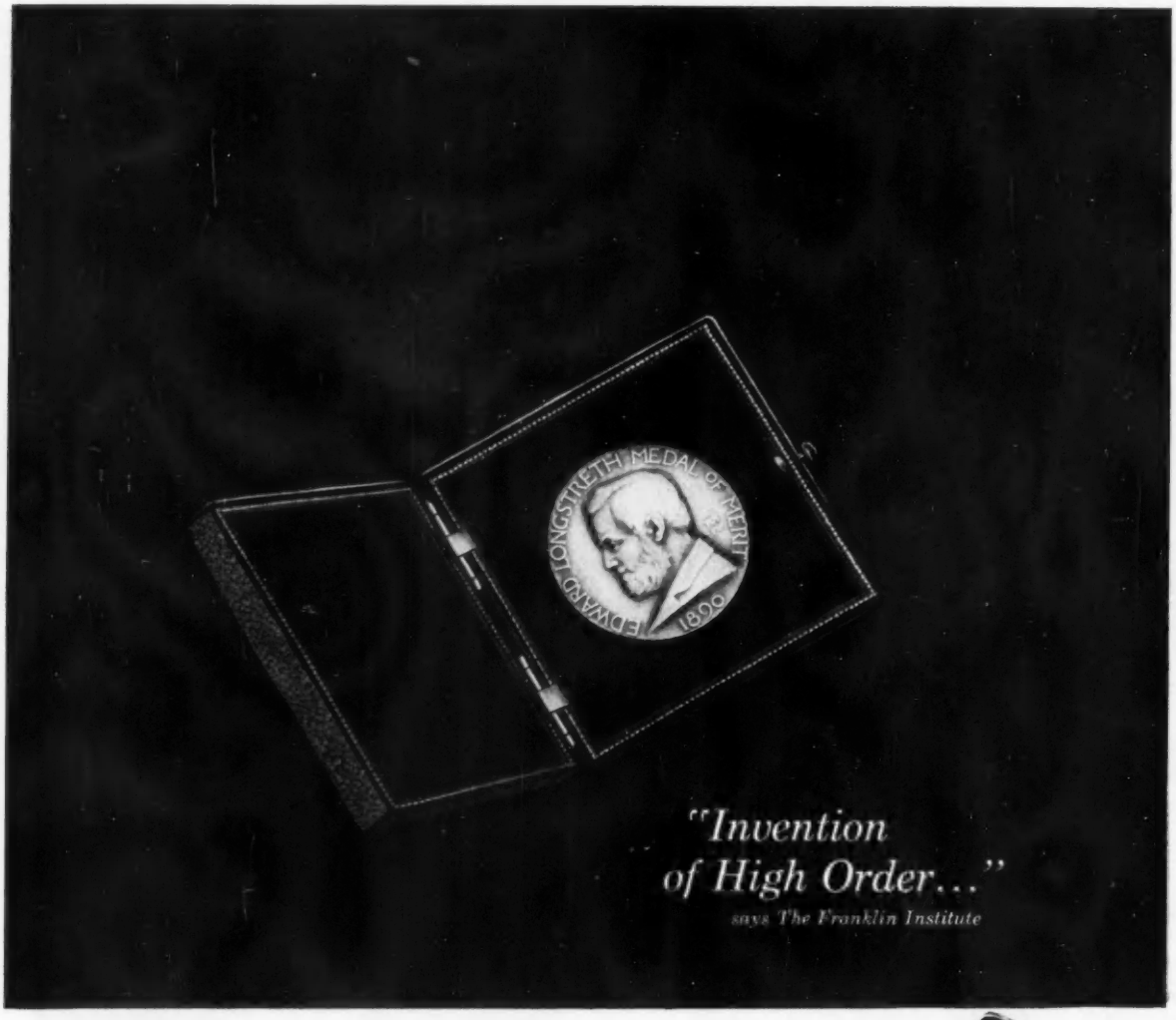
AIRFOAM, a completely new and different cushioning medium, is not in lock-step with the past—and AIRFOAM Development Engineers, working with foremost automobile manufacturers, are pursuing this timely advantage.

NEW AIRFOAM SEAT-UNITS are replacing old-time bulky assemblies. New economies are becoming routine—and interiors are gaining style, glamour, comfort—AND priceless R-O-O-M!

AND THAT'S ONLY THE BEGINNING! The most recent space engineering by AIRFOAM is creating quite a stir in *forthcoming* lines. May we show you some significant findings? Goodyear, Automotive Products Dept., Akron 16, Ohio.

GOODYEAR

PowerGrip "Timing®" Belt



"For invention of high order and for particularly meritorious improvement and developments in machines and mechanical processes."

These are The Franklin Institute's words in awarding its 1955 Longstreth Medal to the inventor of U.S. PowerGrip "Timing" Belts – the outstanding contribution to power transmission of the decade.

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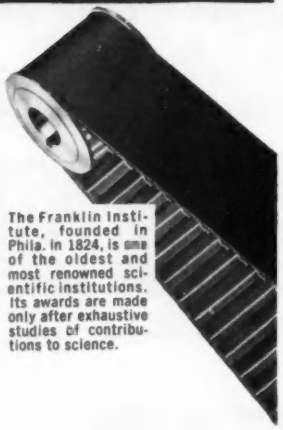
These belts—and descriptive literature—are obtainable from automotive engineering specialists at New Center Bldg., Detroit 2. Phone TRinity 4-3500.



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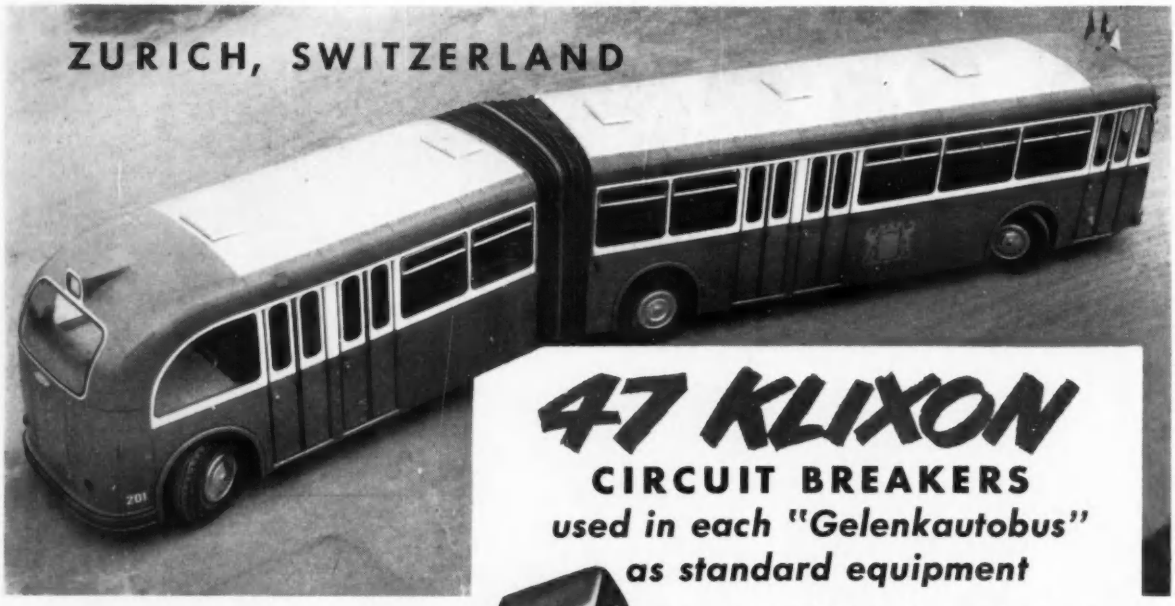


47 KLIXON CIRCUIT BREAKERS

used in each "Gelenkautobus" as standard equipment

In Europe, as in the United States, mobile equipment manufacturers and users alike have learned the value of Klixon Circuit Breakers.

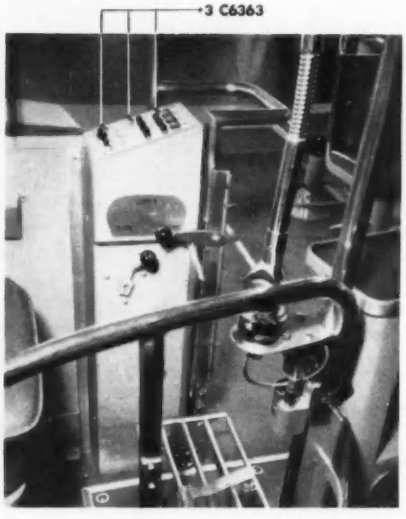
For example, here's what Chief Design Engineer Giovannini, in charge of Electrical Circuits and Maintenance for the Zurich Bus Authority, has to say about Klixon Circuit Breakers:

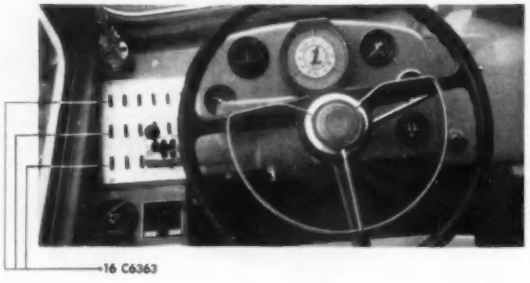
. . . "When we changed over from 6 to 12 volt systems to 24 volts in our motor vehicles, we noticed an increasing number of burned out fuses. These burnouts occurred in such circuits as lamps, signals, windshield wipers, heaters, electro-pneumatic door openers, etc. — with the result that electrical circuit maintenance costs also increased.

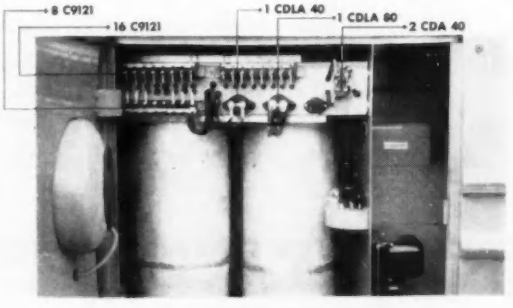
"Since we installed Klixon Circuit Breakers, whose design and construction are simple, strong and reliable, all disturbances and trouble on the electrical circuits have been eliminated.

"The Klixon Circuit Breaker is as of today the most practical circuit breaker for big motor vehicles, especially for public transportation buses. This is particularly so when traffic demands uninterrupted performance on the part of the bus and the driver.

"Klixon Circuit Breakers have done particularly well in our organization and we can recommend them as standard equipment for new buses." . . .







You, too, can get dependable protection for electrical circuits in your motor vehicles by specifying and using Klixon Circuit Breakers. For complete details on design, construction and application of Klixon Circuit Breakers, write today for Bulletin.

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2209 Forest Street, Attleboro, Mass.

KLIXON®

For the Sake of Argument

On Taking a Full Swing . . .

By Norman G. Shidle

Joy has a way of eluding us whenever we do less than the best we know how. The comfort gained by easing up rarely equals the satisfaction of having taken a full swing. A bed of nails seems always jagging up through the mattress of inertia.

When we run out of problems, we run out of lasting joy. Only the very young and inexperienced seriously hope for satisfactions without serving. Like the young man SAE Past-President A. T. Colwell told about the other day: Asked what he meant by "opportunity," a young applicant said: "A large office, my name on the door, a pretty blonde secretary, and a set of golf clubs for frequent use." Colwell suggests that he might better have said: "I know your company has many unsolved problems. I would like the opportunity to take one and solve it . . . and then others, if I am successful."

Summarizing for men of all ages, Colwell concludes: "He must make his opportunity by seeking a problem and solving it, finding a need and supplying it."

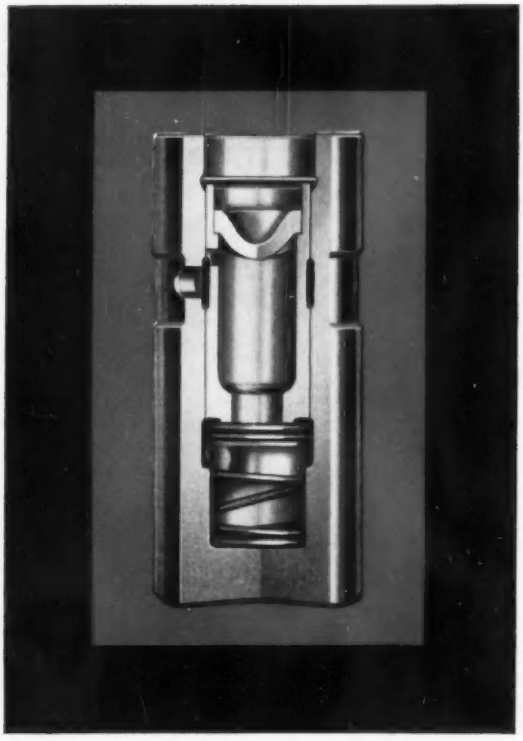
. . . . Which seems another way of saying that the road to success and to inner harmony may be pretty much the same. Both are paved with brick-after-brick of problem-solving and need-supplying.

The common tendency to equate tranquility with drowsiness has little validity. To remain inwardly tranquil, we've probably got to look forward to being bricklayers of some kind all our lives—or find ourselves in a sort of inharmonious comfort . . . where we're not satisfied with what we are doing, but not uncomfortable enough to do differently.

EATON

Zero-Lash®

VALVE LIFTERS



What they do:

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Lancaster, Pa.

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Please address all editorial, advertising, and SAE Special Publications mail to:
29 West 39 Street
New York 18, N. Y.

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SURE, POWER STEERING MAKES THE JOB EASIER. BUT IT'S THE ADDED SAFETY THAT COUNTS MOST.
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The Sky IS

The American airspace is a vanishing natural resource. To conserve it, we must have a comprehensive national aviation facilities system.

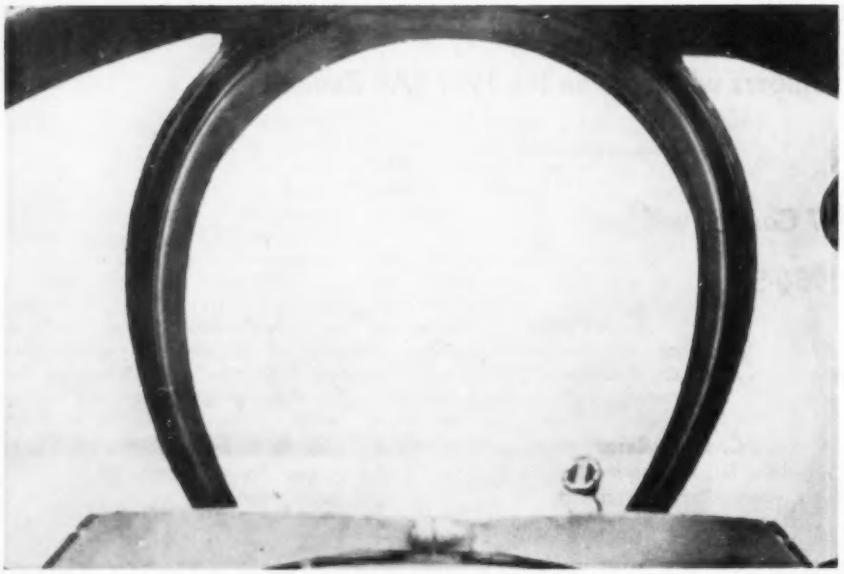
WE are fast coming to a stage where there isn't enough airspace to go around among all the users. The only solution is a national aviation facilities system planned from an over-all consideration of aircraft, airways, airports, navigation and communication equipment.

Of the 15,000,000 cu miles of airspace over this country between sea level and 25,000 ft, some 3,000,000–4,000,000 cu miles are occupied by mountains, tall buildings, television towers, and other obstacles —or else constitute airspace over remote areas seldom traversed by aircraft. About 1,600,000 cu miles are reserved by the government for weapons-testing grounds and other purposes. As much as 1,000,000 cu miles may be subject—due to bad weather—to instrument flight rules, which reduce utilization of airspace 50–70%.

Currently that still leaves 60 cu miles of airspace per airplane, on the average. But there's nowhere near that much in busy areas like the northeast coastal region, even now. Nothing but an up-to-date integrated aviation facilities system can take care of the more critical situation we know will occur in the jet-propelled future.

What can we do about it now?

1. We can think about this problem in terms of a



F-89 APPROXIMATELY 1 MILE AWAY approaching on a head-on collision course is almost invisible. Apparent closure rate is 1000 mph.

The Limit

N. E. Halaby, Laurence S. Rockefeller and Associates

Excerpts from paper "The American Airspace—A National Asset or Menace" presented at SAE National Aeronautic Meeting, New York, April 11, 1956.

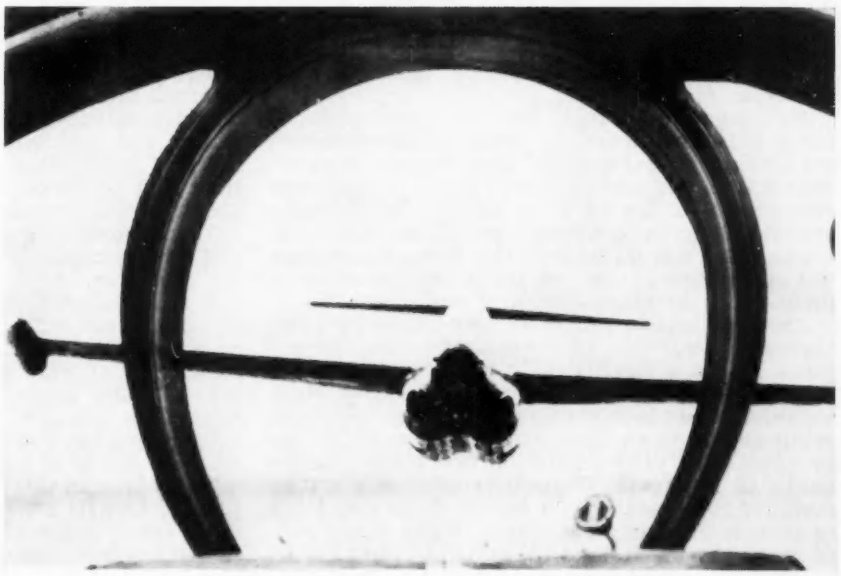
national system. Much progress has already been made in recent months due to the initiative of the Executive Office of the President, the cognizant Congressional committees, and the enlightened national associations.

2. At the same time, we must continue and expedite work on pressing current engineering problems. For example: research and development on proximity indication; on vertical take-off and landing aircraft; high intensity runway and airport approach lighting; making airplanes more conspicuous during daylight; improving cockpit windshield and wiper arrangements; more reliable weather reporting and forecasting; cheap and reliable alternate power sources.

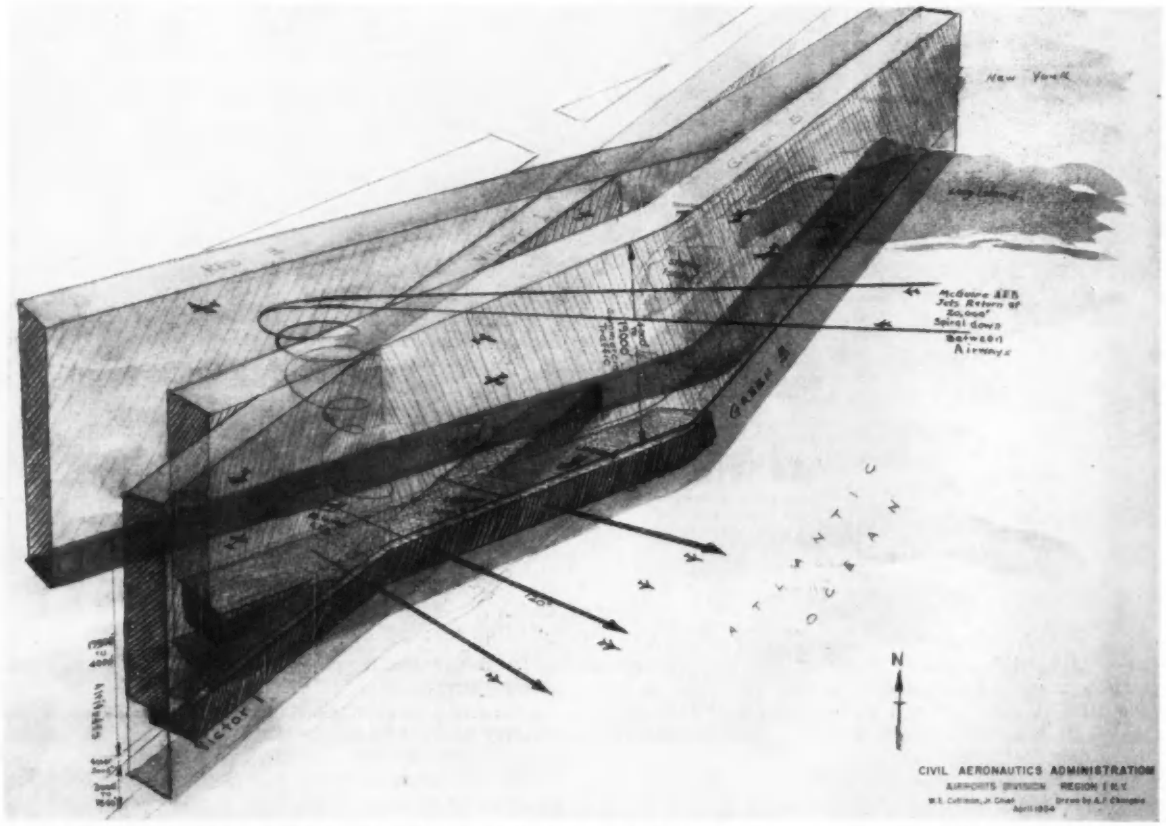
3. We can urge the White House to set up a top priority project to develop a national aviation facilities system in the shortest possible time. This would require mobilizing the best talents and facilities in the United States into a comprehensive, top priority scientific approach to this problem.

To see why our present system is inadequate, take a look at the New York-Philadelphia airspace chart.

Each shaded area represents the protective airspace around the air traffic control holding patterns, indicated by the small black lines inside. These



4 SECONDS LATER the F-89 is almost at the collision point. At higher speeds, there's less time to maneuver.



MILITARY JETS SPIRAL DOWN BETWEEN AIRWAYS from 19,000 ft altitude to runways of big McGuire Air Force in New Jersey. This let-down procedure is necessary because of congestion in airspace between Philadelphia and New York. Departing jets have a long 4000-ft-high tunnel to offshore areas.

safety zones are each 19 miles long and 8 miles wide. For jet aircraft, operational practice may require the size to be doubled or tripled—as much as 57 miles for one aircraft at certain altitudes.

The complexities are obvious. Major military bases like Fort Dix and McGuire Air Force Base dot the area, and considerable express traffic traverses the area.

Jet fighters returning to base come in at altitudes above 19,000 ft, then make their let-down between the airways. Departing jets are provided a "tunnel" 4000 ft high and many miles in length giving them free access to the off-shore areas. Other traffic enroute along these airways cannot use the areas set aside for this jet traffic. This is an extravagant use of airspace . . . but essential for the safety of flight under the present obsolete arrangement.

The pilot holds a rats maze map in his lap as he threads his way into LaGuardia, operating the engines, gear, and flaps; talking to the control tower; peering out of his cramped cockpit to avoid other aircraft; and—incidentally—flying the airplane. While the pilots are thus engaged, there are on the ground a group of long suffering, overworked, underpaid CAA Air Traffic Controllers who use a system designed 20 years ago for a few DC-3s to keep track of present-day airplanes. And, to the amazement of those who understand the state of present technology, this is still being done in accordance with positions reports estimated roughly by the plane's busy crews, voice-radioed to the controllers, written on slips of paper, and passed from hand-to-hand by these able but harassed gentlemen.

On a typical day, there are over 100 aircraft concentrated within a 50-mile radius of the New York terminal area. The mixture of speeds, loads, and missions includes military jets, DC-7s, DC-3s, private planes, and helicopters. They weave among 1250 miles of overlapping airways through 83 intersections and convergences. The pilots will be using about 70 radio frequencies. On the ground, almost 100 controllers depending on party lines and mouth and ear communications will be trying to coordinate the confusion.

It is no surprise that in poor weather under instrument flight rules (IFR) and limited by the capacity of our present air traffic control system, the number of aircraft would be cut in half, and all take-offs and landings from all civil and military airports in this area would be rigorously rationed. One major airline would normally be forced to cancel one third of its scheduled flights!

The reason for this is simple. Handicapped by the present archaic air traffic arrangement, the Civil Aeronautics Administration to be on the safe side in bad weather surrounds each airplane with a co-

coon of airspace 10 min long, 10 miles wide, and 1000 ft to ½ mile thick. You realize how extravagantly the airspace is being used when you see that a small private plane on instruments would get over 60 cu miles; an executive DC-3 about 150; and a DC-7 roughly 275 cu miles. Under this operational practice, each Boeing jet transport will move in reserved airspace of 500 cu miles. Only two could fly between New York and Washington at optimum altitude!

That it may still be safer to fly into New York than to drive in—or to take a bath after you get there—is a tribute to the pilots, the controllers, those few engineers who have devoted real thought to the problem, and to the hard-headedness of the CAA that IFR flights be limited to the capacity of the obsolete airways system.

In the future, I believe you will find that the military will increase rather than decrease the number of areas of the continental airspace which they believe they will require to prove their weapons systems for the air-atomic age. As our vulnerability to attack increases, the demand for these huge spaces grows. A glimpse at a map would indicate that the whole Gulf of Mexico and the long reaches of the Central Plateau Basin may be the only places left for essential missile proving grounds within United States control. Therefore we can expect further needs for critical airspace in the name of our national security.

Besides, the communications industry is planning and will install a larger number of television towers, relay stations, and such space-consuming equipment. Tall structures will continue to rise on the approaches to airports. A huge expansion of heavy industry is underway with increasing likelihood of thicker and wider smog areas. And aeronautical engineers are lying awake nights devising new occupants of the airspace!

If we look at the numbers of manned conventional aircraft, an increase of only about 30% should be expected in the next 15 or 20 years. But there will be a very great increase in the number of airplane movements because the fleet will be composed of much faster types. Assuming the same daily utilization rates, the DC-8 can make almost twice as many trips as the DC-7. Likewise the Electra's productivity may be as much as twice that of present Convairs.

Here, we must guard against a tendency to overestimate the importance of the scheduled airlines in thinking about this problem. Although they get the highest daily utilization in movements per plane, they comprise by far the smallest number of users of the airspace. At present there are about 1200 or 1300 scheduled airliners, and there will probably be only 300 to 500 more by 1970. Currently the military fleet and the general aviation fleet are respectively about 25 and 45 times the size of the airlines. Of the 61,000 airplanes in general aviation, about 20,000 are now called business aircraft or the executive fleet. Growth in numbers (15% more in 1955 than in 1954) and in flying hours (about 30% for the same period) has been phenomenal. With the greater performance, reliability, and comfort coming off the drawing boards, the trend is ever upward.

A less predictable growth factor occurs in the field of the quick-risers. If the steep landing and takeoff machine or even a variation of the helicopter should achieve mass production and an economy comparable to bus or train, this projection would of course prove to be pitifully pessimistic. And does anyone doubt that out of the present menagerie of all types and shapes of vertical risers some cheap air bus will eventually arise?

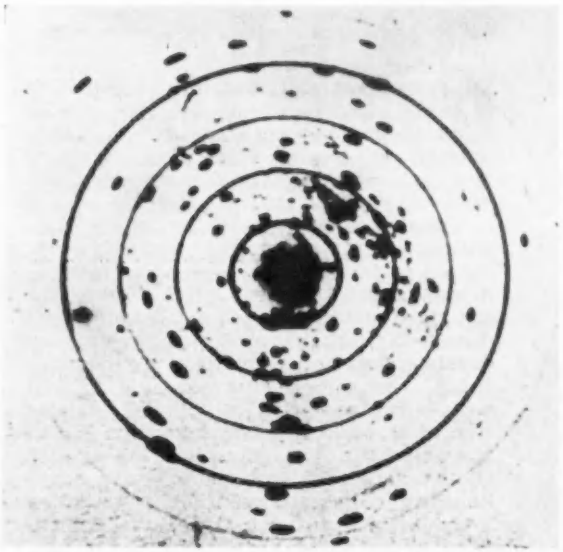
Forecasts of air freighter traffic are also highly uncertain due largely to developments in military logistics, but should costs per revenue ton-mile be reduced more rapidly than is now anticipated, here would be another prolific source of traffic headaches.

Speed and general performance will certainly increase remarkably over the next 20 years, with transcontinental and intercontinental supersonic transports arriving toward the end of the period.

All the trends are in the wrong direction. More planes at higher speeds mean greater danger of collisions. Soviet aviation progress means greater menace from abroad, therefore more military flights and airspace reservations at home and more inefficiency and waste due to congestion of airways, airports, and communications.

On the civil side, it would seem to me that the present air fleet is more likely to prove inadequate both in quantity and quality than to be excessive and even the huge capital outlay projected for jet and turboprops would not be sufficient to keep pace with our projected traffic volume.

On the military side, insofar as congestion is concerned, the greatest hope would be that push-button missiles would promptly replace manned aircraft. This would conveniently relieve us of the fighter and bomber traffic. We are assured on all sides, however, that this will not be the case. I suspect that for some time at least missiles will be superimposed on the aircraft inventory. My guess is that between 1965–75 the number of active interceptors, long range fighters, and certain types of bombers will



PHOTOGRAPH OF CAA RADAR SCOPE AT MITCHELL FIELD, Long Island, New York, taken on Aug. 27, 1955. Rings are 10 miles apart. Each spot indicates location of one airplane in plan view. (Large dark area near center represents reflection from ground objects.)

tend to diminish as reliable missiles are perfected to do their job. But there is certainly no early likelihood of any fewer administrative aircraft or logistics aircraft or a major reduction in the number of strategic bombers in the military air fleet.

So far as communications facilities are concerned, it is perfectly clear that the large numbers of aircraft annually multiplying the number of air movements can no longer efficiently use a voice communications system which has had no substantial modification in many years. Numerous frequency bands on VHF and UHF, as well as low frequency bands, are being used for everything from IFR position reports to personal messages regarding crew and passengers. In the day of digital data links and storage devices and voice-code transducers we can no longer be satisfied with a system limited to broadcast voice communications over air-to-ground party line and the regular telephone circuits for coordination between centers on the ground.

As to aerial navigation, it is important to recognize navigation as merely one of the functions and components of a total system designed for use of all. The impassioned controversy over VOR/DME versus TACAN is no tribute to our maturity and ability for planning in terms of the public welfare rather than departmental or company interests. When we forget that the American airspace is a national asset to be conserved and used for the benefit of all, when we ignore the collective for the individual interest, we get into both political and technical trouble. And so it will continue to be until we conceive a national system and develop it as such.

What we must have is a national aviation facilities system of airplanes, airways, airports, navigation, and communications that will meet the foreseeable civil and military needs for the most efficient utilization of our continental airspace.

"National" is perhaps the key word here because national leadership can submerge departmental interests, can compose or choose between civil versus military conflicts, can counter state or local pressures, and can mobilize the immense resources of the federal government on this top priority national problem.

Here are the steps to be taken to achieve such a national system:

1. Establish a set of long-term national requirements. We should bring users, operators, and controllers together with economists and engineers in a systematic effort to define facilities requirements for two periods: 1960–1965 and 1965–1970. Currently neither the CAA nor the military services have dependable estimates on long range needs. A great many factors need to be considered—factors like population, gross national product, disposable income, traffic to and from pairs of cities, correlation

We Can't Afford NOT to Have

Stuart G. Tipton President, Air Transport Association

Excerpts from "Tomorrow's Magic Web" presented at SAE National Aeronautic Meeting, New York, April 11, 1956.

NO system yet exists which will adequately control tomorrow's planes in tomorrow's numbers at tomorrow's speeds. To put it bluntly, our country's air power, military and civil, will be handcuffed unless corrective action is taken—promptly.

Actually, the present system of air navigation, landing, and traffic control is a collection of devices improvised as operational demands dictated. And what is more, the individual devices in use are still being used despite the fact that modern, more efficient developments and techniques are available today. An outstanding example is that voice communication is still the foundation of all air-traffic control today, just as it was in the first controlled flight, even though more efficient methods are available and in common use in other activities.

The lack of modern efficiency and flexibility in the current air-traffic control system results in extravagant use of airspace to maintain the required level of safety. For example, when an airspace reservation is established—a reservation in which normal aviation activities cannot be conducted—buffer areas to add an extra margin of safety are included. As another example, separation of aircraft travelling in the same direction at an identical altitude on the airways is a minimum of 10 min. This means that the mileage separation depends upon the speed of given types of aircraft. It would be 50 miles with airplanes travelling at 300 mph. With jets, the required mileage separation would be considerably greater.

The CAA points out that "using the present methods of separation, we could allow only two jet transports to be travelling from Washington to New York at the same altitude at the same time."

The solution to this problem is difficult. But we had better find it.

And let me add that we do have the knowledge and the ingenuity in this coun-

with international traffic, airplane performance and productivity, military inventory and operations, air cargo economy, air bus estimates, and documented estimates of airplanes per hour per cubic mile or per airway or airport.

2. Design a national aviation facilities system. Good ideas can be borrowed from the Air Defense System, the Atomic Energy Program, and the Bell Telephone System.

The project must be comparable in scope if not in size to Project Lincoln if it is to do the systems planning and engineering on airspace utilization, traffic control, communications, navigation, and airports needed to weld together a truly adequate national system. The project will need a facility for system stimulation and development testing—plus the priority, manpower, and money to do the job in the best interests of all the airspace users.

3. Finance the system. It will be costly, but much less costly than going without the system.

4. Finally, solve the problem of organizing and managing the system. This won't be easy with all the civil-versus-military, user-versus-Treasury, federal-versus-local, and big-versus-little user implications.

What might such a national system look like in 1975?

Since we will soon have invested $3 billion in a national air defense radar system for detecting, identifying, tracking, and intercepting aircraft flying through our airspace, we must start with the premise that whatever is useful in this system for common civil-military airspace utilization will be available and fully exploited. This does not mean complete dependence on SAGE (Semi-Automatic Ground Environment) but does mean getting as much double duty out of these dollars as possible.

A second premise seems inescapable. The airspace will need to be classified in some sensible and equitable way to provide for its optimum use. Sportsmen, farmers, photographers, instructors, and business executives (even engineers!), as well as the airlines and the military, must get their share of the air. Perhaps these studies will conclude that there should be three classifications of the airspace —*Free*, *Monitored*, and *Controlled*. Obviously, only a small amount of the total airspace need be in the third category, perhaps that over 20,000 ft and around certain designated zones and air paths. In the Monitored Airspace, positive separation service would be provided at all times to all pilots. In the wide open and low altitude spaces, "the winds of freedom" would continue to blow!

If the cost of building, manning, and maintaining a system that would accommodate all in the most critical areas should prove to be unbearable, then some equitable classification of pilots and aircraft by skill and equipment might be necessary during

Efficient Air Traffic Control

try to invent a bold, new, revolutionary system of air traffic control which will be able to accommodate the volume and complexity of tomorrow's air traffic.

Experts on the subject say that steps should be taken immediately to install at a greatly accelerated pace the air-traffic control devices presently available. There is much that can be done right now to bring greater safety, capacity, and flexibility to the present interim system by making maximum use of available tools. Radar is one such tool and its use must be expanded greatly.

Simultaneously, steps should be taken to develop the bold, new, revolutionary, future system able to provide affirmative control of an aircraft from the moment it leaves the ground until it touches down again at the airport of destination. Needless to say, such a system must accommodate military as well as civil movements. And it cannot be emphasized enough that such a system is of the utmost importance to the nation's continued ability to defend itself.

Most of the devices for the needed new system are already in existence. Research is needed to determine exactly what the character of the new system should be and how the separate elements can be properly integrated to constitute the new system. That research will require much time, much effort, and our best brains.

The imperative thing is that we begin the development of the new system at once.

And there is heartening evidence that such development may soon be initiated.

As the newspapers have announced, an aviation subcommittee of the Senate Committee on Foreign and Interstate Commerce, known as the Monroney Committee, has undertaken a study which includes an examination of the nation's current air traffic status and future requirements.

Also, the Bureau of the Budget has completed a report on the subject under the guidance of William Barclay Harding.

And more recently, President Eisenhower appointed Edward Peck Curtis as a Special Assistant for Aviation Facilities Planning. His job is to head up an attack on the problem of developing an air traffic control system suited to the country's future needs.

For complete paper on which this abridgment is based, write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

peak hour operations. (Even now, we keep trucks off our parkways, limit "hot rods" to deserts and beaches, and make it increasingly intolerable to drive downtown in Los Angeles or Chicago.)

Again taking the New York area as a dramatic example, it is estimated that there would be around 450 to 550 operations per peak hr. It is probable that if the system could handle the peak New York load, it could deal with the other critical areas such as Chicago, Miami, and Los Angeles.

Obviously, for the few major traffic hubs, some very flexible positive electronic control plus semi-automatic communications would be required to handle all the dynamic variables and compute and schedule the close spacing with safety required into a number of all-weather runways.

A combination of air and ground derived data will serve air navigation and traffic control, with minimum airborne equipment being needed in the Free and Monitored Airspace.

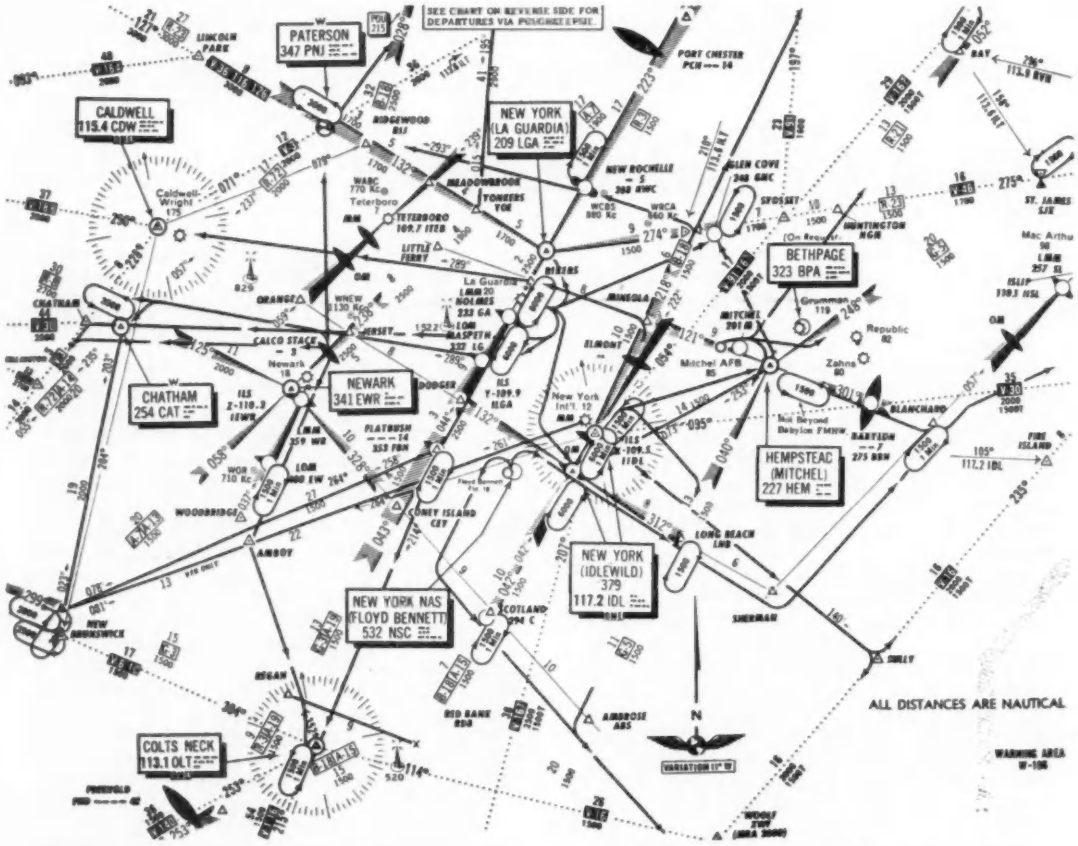
Human monitors will have pictorial and tabular air situation displays so as to intervene at any moment.

Since the system must serve air commuters and flying farmers as well as supersonic DC-11s and F-200s, there will have to be some combination of data links for the electronically rich and canned voice communications for the poor.

Air navigation, largely to complement ground data or to substitute in case of failure, may be by rho-theta radio navigation, or fan marker, or DR, or some combination displayed pictorially or fed into an autopilot. The pilot will need to talk to the ground only to report some emergency or to confirm his identification, which his small airborne transponder will normally provide. In any case, the system will have to fail safe, and the pilot will undoubtedly demand some last resort under his own control as the price of putting himself into the harsh hands of the automatic system.

Because of terrain obstacles, ground return, and other problems, radar alone cannot serve the helicopters and vertical users. So some supplemental system will be needed, particularly if air buses fill the sky with commuters.

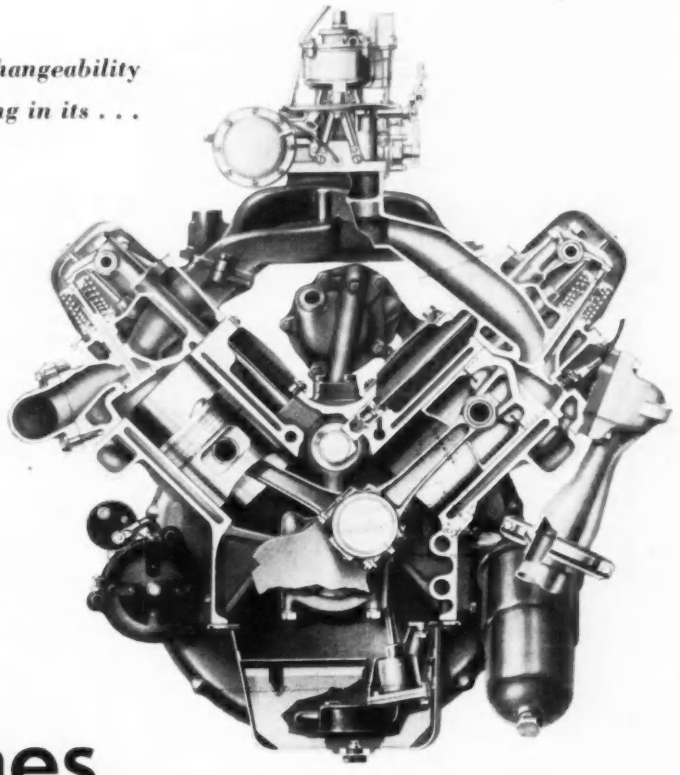
For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.



PILOT'S LAP MAP OF NEW YORK AREA is complicated enough to keep him busy following it as he approaches airport—but he also must be operating engines, landing gear, flaps . . . talking to the control tower . . . peering out of his cramped cockpit to avoid other aircraft . . . and flying the plane.

International Harvester stresses interchangeability of parts and common production tooling in its . . .

New Family of V-8 Truck Engines



G. R. Beardsley and A. A. Catlin

Motor Truck Division, International Harvester Co.

Based on paper "International Harvester's Approach to the V-8 Engine Program" presented at the SAE Summer Meeting, Atlantic City, N. J., June 8, 1956.

INTERNATIONAL HARVESTER's new family of three V-8 truck engines has been developed to provide gross power ratios of 206, 226, and 257 bhp. With each engine having the same installed length, 40 in., they are manufactured with essentially common tooling. Most of the parts of the three engines are interchangeable. They differ chiefly in the use of two cylinder bores and two crankshafts.

All engines use standard grade fuels. Model 401 has a 7.5/1 compression ratio and the larger engines 7.0/1. Special attention was paid to reducing weight, which is critical and costly in trucks, by eliminating "lazy metal" in crankshaft, crankcase, oil coolers, and air compressors.

By designing a family of engines, International Harvester has achieved engine weights of 4.5, 5.0, and 5.4 lb per hp. The comparatively small, compact, light, heavy-duty engines can be mounted within the standard 34-in. frame spacing.

Fuel economy is reported to be about 110 to 120

Engine Specifications

	V-401	V-461	V-549
Bore (in.)	4-1/8	4-1/8	4-1/2
Stroke (in.)	3-3/4	4-5/16	4-5/16
Displacement (cu in.)	401	461	549
Gross Torque (ft-lb)	355 @ 2000 rpm	420 @ 1800 rpm	505 @ 2000 rpm
Gross Power (bhp)	206 @ 3600 rpm	226 @ 3600 rpm	257 @ 3400 rpm
Weight (lb) with standard accessories	1089 lb	1095 lb	1108 lb
Compression Ratio	7.5/1	7.0/1	7.0/1

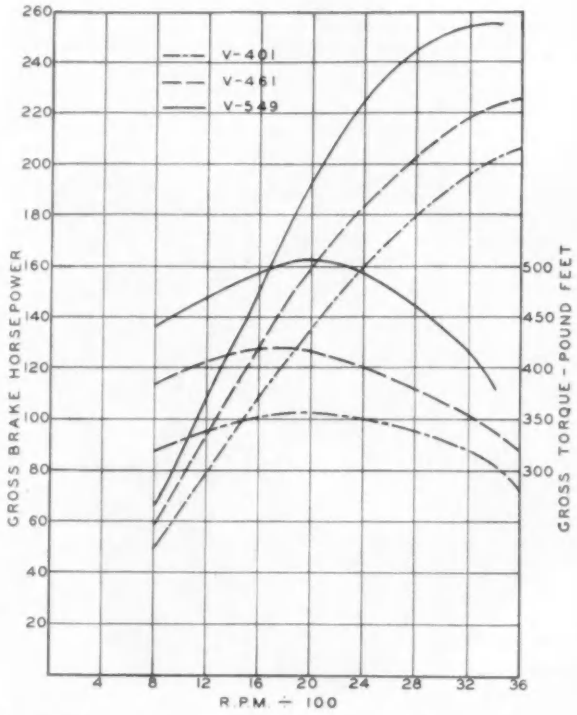


Fig. 1—To span horsepower needs in the truck industry, International Harvester developed three engines with different power and torque characteristics.

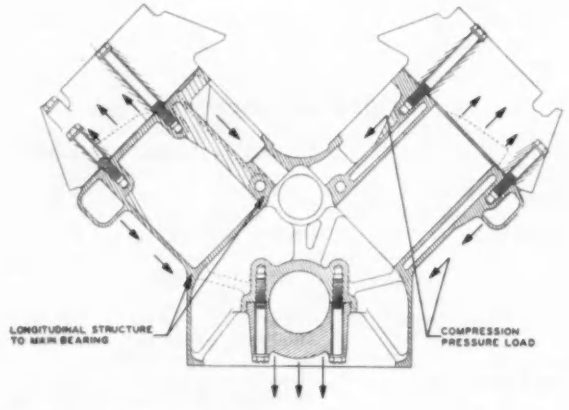


Fig. 2—Cylinder head loads are carried through the outer water jacket walls to the main bearing bulkheads. This eliminates barrel distortion.

ton mpg for 100,000 miles of endurance testing at average speeds of 38 to 42 mph.

Bearing loads are distributed

In designing the crankshaft and connecting rod bearing loads, a basic design parameter of 760 psi peak combustion pressure was used. The design parameters for engine operating conditions were peak torque at 2000 rpm, maximum power at 3500 rpm, and maximum speed, no load, at 4500 rpm.

A main bearing length/diameter ratio of 0.30 was selected to provide maximum bearing cooling and full area contact without localized edge loading. Design bearing pressures of 3500 psi for connecting rods and 2500 psi for main bearings have been used and proven satisfactory. A firing order of 1-8-7-3-6-5-4-2 permits the lowest combined bearing loads with the crankshaft bearing spacing. A copper-lead-tin plated bearing material was selected for use with hardened journals.

Cylinder heads are interchangeable

The cylinder heads are made of stress-relieved cast iron. They are interchangeable on the three engine sizes. Common inlet and exhaust passages, as well as common valve sizes, are used for all three engines. Foundry equipment and manufacturing tools are essentially the same. The combustion chamber profile and the lower jacket core are varied so that the same material section is maintained adjacent to the combustion chamber on all heads. Engine tappets can be serviced easily by removing the valve covers.

Cylinder barrels are supported only by the top and bottom decks, as shown in Fig. 2. Combustion load reactions were considered separately for each bank of cylinders. The external longitudinal walls are the stress members which tie the cylinder heads to the transverse bulkhead walls containing the main bearing seats.

Six bolts per cylinder, as shown in Fig. 3, are used to clamp the head and transmit gas pressure to the outer jacket wall.

Crankshafts are induction hardened

Crankshafts are fabricated from SAE 1046 steel. They are induction hardened and weigh 96 lb. A vibration damper is used on the V-549 and V-461 engines. The journal overlap resulting from common bearing diameters and reduced stroke in the V-401 engine decreases torsional stiffness and eliminates the need for a damper. The vibration characteristics of the three engines are shown in Fig. 4.

Aluminum pistons are lightweight

Pistons are made of tin-plated aluminum. The double transverse slot pistons, as shown in Fig. 5, were designed to transmit gas loads from the contour head to the pin bosses with a minimum variance in deflection and stress. A cross slot in the oil ring groove provides for oil drainage and a maximum crosshead length. The pins are made of plain carbon steel and case hardened on the inside and outside diameters. The maximum piston speed is 2300 fpm at 3200 rpm (in the largest of the three engines).

Enbloc Crankcase has low pan rail

The enbloc-design crankcase is made of slow-cooled alloy iron with the pan rail below the crankshaft centerline, as shown in Fig. 6. Five main bearings, carried on bulkheads, blend with large fillets into adjacent members to distribute dynamic stress and reduce residual casting stress. Main bearing caps are made of high alloy iron. The rear bearing cap carries a rope-type seal. It has drain holes to return oil to the crankcase. Four camshaft bearings are used.

Provision for producing two bore sizes has been accomplished by two sets of jacket and bore cores in the foundry equipment. The jack core assembly is common to both banks. All crankcase cores are jig set for accuracy and reduced foundry costs.

Valve gear is specially designed

Instead of mechanical tappets, hydraulic tappets are used to avoid noise and service adjustments. The same type camshaft is used by the three engines. Cam design follows a modified polydyne method which considers the effect of valve gear flexibility. A constant acceleration ramp is used on the common intake and exhaust cam profile. The valve lift is 0.420 in. and the opening duration is 260 deg.

Dual valve springs with a total valve-open load of 210 lb have proved satisfactory to 400 rpm. The tappet body is made of high strength cast iron with a chilled iron face. The camshaft is a steel forging with the lobe profile surfaces hardened and polished to a smooth finish.

Intake valve stems have rubber umbrella seals which control lubrication of the valve guides. Intake valves are made of Silcrome XB. Sodium exhaust valves are used in the V-549 and solid exhaust valves in the V-461 and V-401 engines. The exhaust valves rotate.

Induction system

A four-barrel carburetor is used on the large engine and a two-barrel carburetor on the two smaller engines. Intake manifold area is changed accordingly. A differential pressure surge system between the four center cylinders provides an exhaust-heated hot spot for quick warm-up. Low resistance oil bath and treated paper air cleaners are used. The carburetor air intake can be either outside or under the hood.

Cooling system gives uniform temperature

A high pressure system combined with high velocity scrubbing action and directional control provides optimum cooling. A single, high pressure, high volume water pump discharges into two manifolds integrally cast along each cylinder bank. The area of this manifold is progressively reduced to maintain a constant velocity throughout its length. Each cylinder is supplied with cooling water by sets of metering holes fed from the water distributing manifold. The water impinges on the combustion chamber walls, spark plug bosses, and exhaust valve seat areas.

A dividing wall extends the length of the cylinder head, separating the water jacket into high pressure and low pressure areas. Metering holes in the criti-

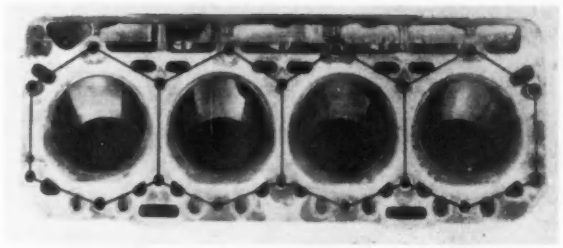


Fig. 3—Six bolts per cylinder are equally spaced for clamping the head and transmitting gas pressures to the outer jacket wall.

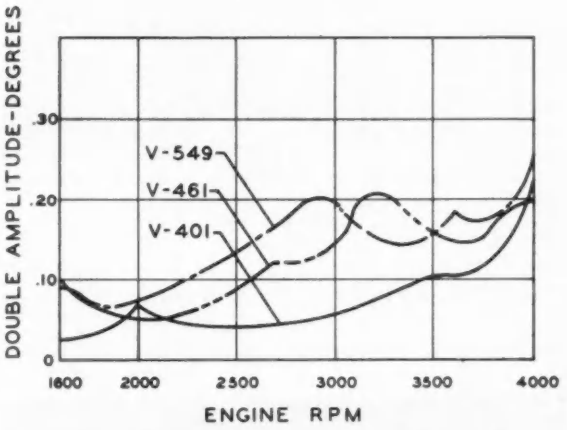


Fig. 4—V-401 engine has the least crankshaft vibration of the three engines, due to its shorter piston stroke.

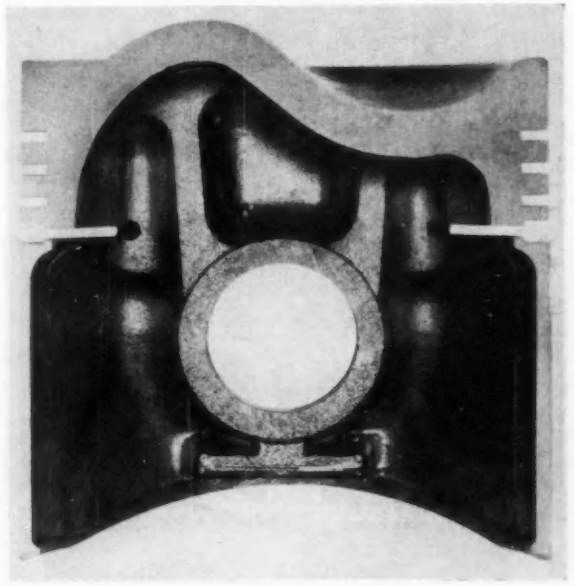


Fig. 5—The contoured piston is made of light-weight, heavy-duty, tin-plated aluminum.

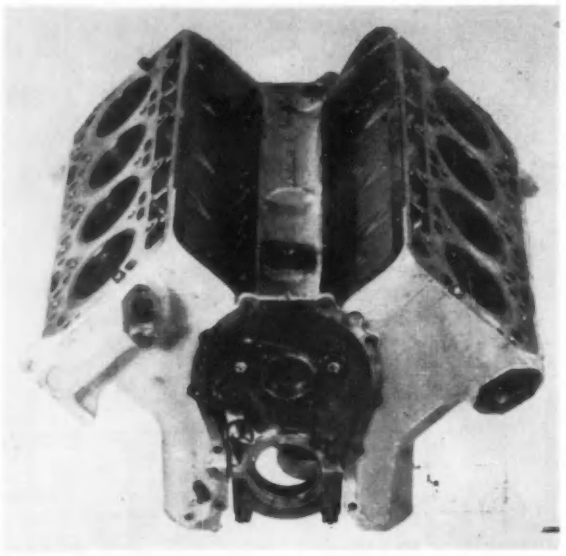


Fig. 6—The crankcase has the pan rail below the crankshaft centerline.

cal areas of exhaust guides, exhaust seat inserts, and combustion chamber walls establish pressure differentials. Coolant flows through these holes with controlled direction and quantity. The coolant then flows from the low pressure area to the engine thermostats and into the radiator.

A wet exhaust guide insures maximum heat transfer from the exhaust valve. (See Fig. 7.) Stepped diameters and an undercut in the area exposed to the cooling water facilitates assembly and removal.

A balance tube connects the distributing manifold on either bank to compensate for minor casting and pump discharge variations. This tube is also used to supply the engine oil cooler with coolant from both cylinder banks.

A dual thermostat by-pass system is used for rapid and uniform engine warm up. Each cylinder head has a thermostat mounted in the water outlet to reduce restriction losses.

Lubrication system

The engine lubrication system is shown schematically in Fig. 8. The 15 gpm oil pump is at the rear of the engine. It is supplied with oil through a fixed screen near the center of the oil in the pan. It delivers oil to the oil galleries through a combination full-flow filter and partial-flow filter. A triple-pass oil cooler is standard on the largest engine and optional on the two smaller engines.

For complete paper on which this abridgment is based write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

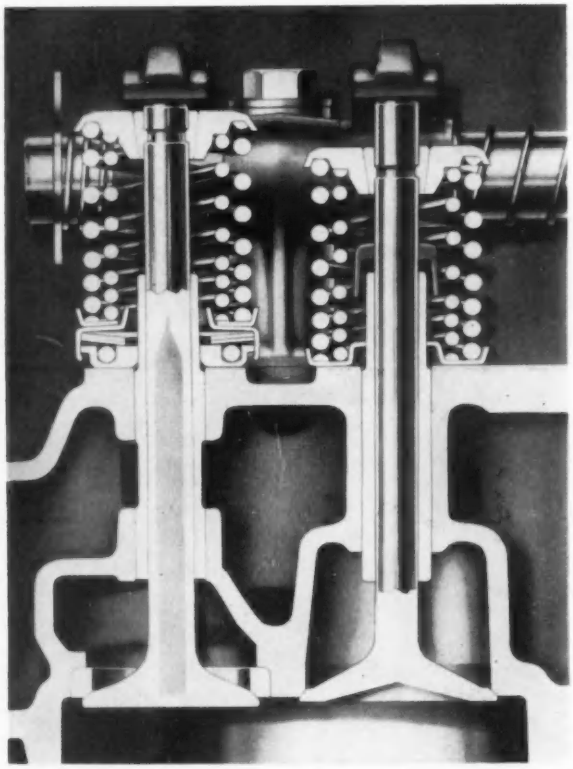


Fig. 7—Wet exhaust valve guide draws as much heat as possible from the valve. Inlet valve guide is conventional.

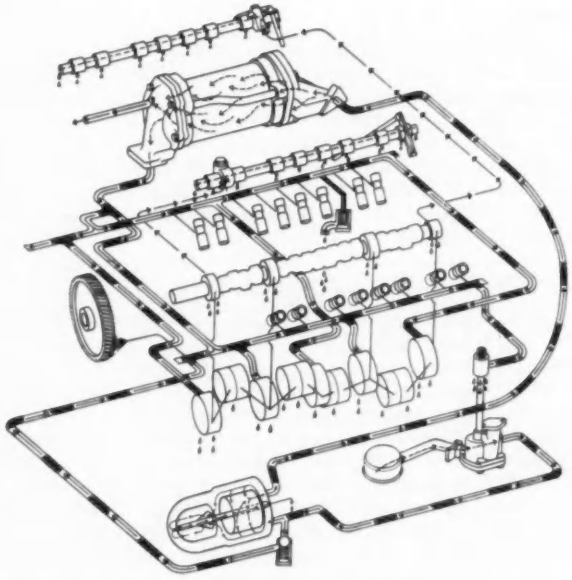


Fig. 8—Lubrication system has 15 gpm capacity.

Some Answers to

Multigrade Oil Problems

PROPER selection of both base oil and viscosity index (V.I.) improver is an important requisite for a multigrade oil, if it is to fulfill two necessary functions of a high-quality engine lubricating oil, which are to provide:

1. Good oil consumption under all conditions.
2. Easy starting at low temperatures.

Presented here are the results of some research work that covers these two phases of oil blending. (Good wear properties and freedom from sludge and other deposits are not considered.)

Oil Consumption

Oil consumption of multigrade oils depends on many factors, among them being:

1. Oil volatility.
2. Oil viscosity.
3. Type of V.I. improver used.
4. Sensitivity of engine to viscosity and V.I. improvers.

When there is a proper balance between base oil and V.I. improver, so that the volatility, the high- and low-temperature viscosities—and other properties—of the finished oil are just right, it is indicated by both authors and discussers that this oil will give oil consumption rates that compare satisfactorily with those of oils of conventional grades. The problem is that, since multigrade oils are still relatively new, we don't yet know just how to select the components to give the perfect blend. Many laboratories are working on this problem, however, and they are providing information that is helping to fill in the gaps in our knowledge about compounding multigrade oils.

Overcash et al. tried to show that the viscosity at

Symposium on Multigrade Oils

THIS ARTICLE is based on the following material:

Relationship of Low-Temperature Cranking Resistance to Viscosity Characteristics of Multigrade Oils
G. K. Malone and T. W. Selby, GMC

Cold Starting with V. I. Improved Multigrade Oils
F. B. Fischl, H. H. Horowitz, and T. S. Tutwiler,
Esso Research & Engineering Co.

How Do Volatility, Viscosity, and V. I. Improvers Affect Oil Consumption?
R. L. Overcash, W. Hart, and D. J. Mc Clure,
Kendall Refining Co.

Discussion of these papers by:
F. S. Wood, Standard Oil Co. (Ind.)
W. P. Lakin, Union Oil Co. of Calif.
V. W. Ware, Rohm & Haas Co.
J. A. Miller, Calif. Research Corp.
H. V. Lowther, Socony Mobil Laboratories

These papers and discussions were presented at the SAE Annual Meeting, Detroit, Jan. 13, 1956.

The above papers are available in full in multilith form from SAE Special Publications Department. Price: 35¢ each to members, 60¢ each to nonmembers. (The Malone-Selby and Fischl-Horowitz-Tutwiler papers are also published in full in the 1956 SAE Transactions.)

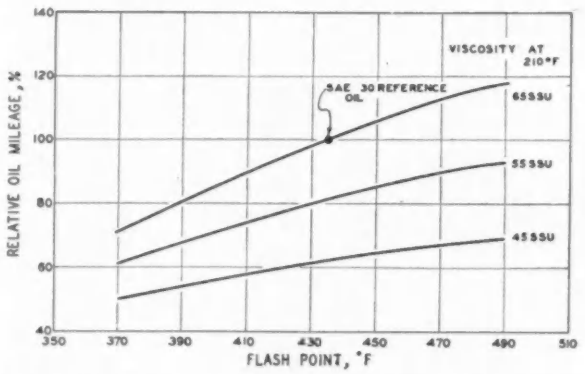


Fig. 1—Effect of viscosity on oil consumption for series of oils under 30-hp test conditions. Viscosities of oils ranged from 2.0 to 6.0 centistokes at 350 F. Reference oil had viscosity of 2.9 centistokes at 350 F (from Overcash et al.).

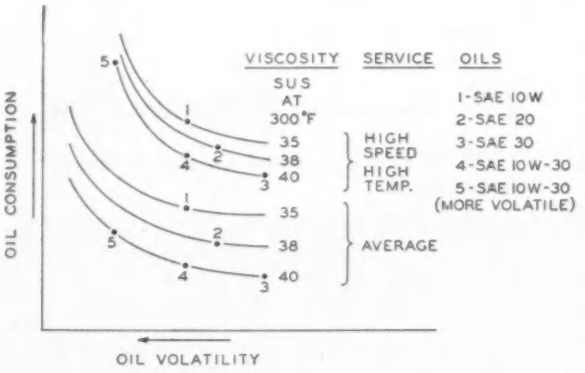


Fig. 2—Oil consumption versus oil properties and engine operating conditions (from Lowther).

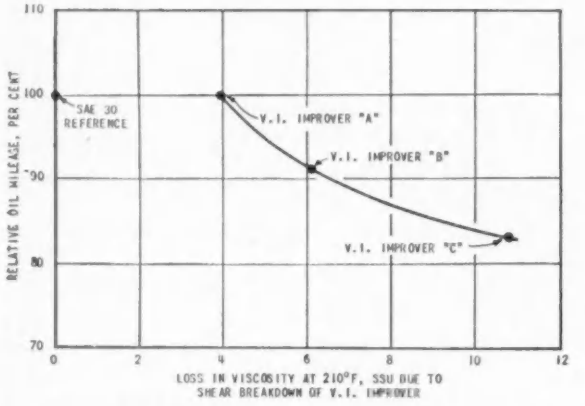

RELATIVE OIL MILEAGE, PER CENT
SAE 30 REFERENCE
V.I. IMPROVER "A"
V.I. IMPROVER "B"
V.I. IMPROVER "C"
LOSS IN VISCOSITY AT 210°F, SSU DUE TO SHEAR BREAKDOWN OF V.I. IMPROVER

Fig. 3—Effect of shear stability of V.I. improvers on oil mileage of V.I. improved oil (from Miller).

350 F, which is assumed to be the cylinder-wall temperature, correlates with oil consumption. For instance, Fig. 1 shows some of his test results, in which oil consumption decreased with increased viscosity at 350 F for a series of oils of equal volatility effect.

Lowther, on the other hand, has found that a good correlation exists between viscosity of V.I. improved oils at 210 F and oil consumption. He suggested further that oil consumption may not always be related to cylinder-wall temperature, but may be influenced by the temperature of other engine areas.

Miller has also found that lab and field tests with most types of automotive engines give a good correlation between oil mileage and viscosity at 210 F. He suggests that whether viscosity or volatility is the controlling factor depends on driving conditions:

1. Under high-speed, high-temperature conditions, volatility is the primary factor governing relative oil consumption.

2. Under average service, where both city stop-and-go and moderate-speed service is encountered, volatility is less of a factor and viscosity becomes more important.

3. Under very light-duty service, the viscosity lines flatten out to a greater extent and volatility becomes even less important.

The first two of these conclusions are illustrated by Fig. 2. Points are plotted for five oils: conventional SAE 10W, 20, and 30 oils and two 10W-30 oils, one being more volatile than the other. Note that under high-speed conditions, there is a large difference between the multigrade oils of different volatilities, the more volatile oil giving far higher consumption. Under average driving conditions, on the other hand, the more volatile oil comes down within the range of the other oils, although it still does not give consumption comparable to the less volatile oils of equal viscosity.

Studies of V.I. improved oils also show that the type of improver has a great influence on the performance of the blend. One of the important factors appears to be the molecular weight of the polymer used as the improver. Thus, high-molecular-weight, polymeric improvers are subject to rupture by shear in an engine, according to Miller. The breaking up of the large molecules, he reports, causes a loss in oil viscosity, causing reduced oil mileage. The higher the molecular weight of the polymer, the greater the loss in viscosity. Fig. 3 shows the relative oil mileage he obtained for three oils made from the same neutral, thickened to the same viscosity at 210 F. Three V.I. improvers of the same type were used, but that had increasing molecular weight. Oil mileage of the V.I. improved oil used as reference (V.I. improver A) was the same as that of a conventional SAE 30 oil that did not show a viscosity loss with use. This mileage was 1200 per qt. Note that a decrease in viscosity at 210 F due to shear of 4 SSU can be tolerated without adverse effect on oil mileage, while a shear loss of 11 SSU reduces oil mileage by almost 20%. This loss in oil mileage due to shear breakdown of the V.I. improver is less than that reported by Overcash et al.

Both Miller and Overcash et al. observed that loss in oil mileage caused by breakdown of V.I. improver of low shear stability varies with drain period, mechanical condition of the engine, and operating conditions. Thus, short drain periods and high rates of adding make-up oil minimize differences in mileage between oils of different shear characteristics, while extended drain periods and low make-up rate accentuate differences. Miller reported, however, that he had not observed this phenomenon with oils blended with a V.I. improver of high shear stability. Moreover, he found that when shear stability and volatility are adequate, mileage of a V.I. improved oil is equal to or better than that of a conventional oil of similar volatility and viscosity at high temperature, regardless of the service in which the oil is used.

Wood pointed out that differences exist in the sensitivity of engines to viscosity and V.I. improvers, so that in any test program several engines should be used to obtain statistical results. Table 1 illustrates this point for three cars that were run in a controlled oil mileage test. The 20W-40 oil had the same viscosity at 300 F as the 40 oil. Car A was insensitive to the viscosity of the 40 oil but did respond to the V.I. improved oil. B was sensitive to the 40 oil but relatively insensitive to the V.I. improved oil. C, on the other hand, was responsive to both oil viscosity and V.I. improver and was typical of about 20 other cars included in the program.

Cold-Weather Starting

To recommend the correct multigrade oil for the temperature ranges previously served by single-grade oils, especially for low-temperature operation, is not easy. Reason: viscosities of multigrade oils change with temperature and shearing conditions in a manner quite unlike that of conventional mineral oil lubricants.

That is why the usual method of determining oil viscosity at 0 F by extrapolating on the ASTM chart from measured viscosities at 100 and 210 F has proved unsatisfactory for the new oils. For example, some of the 10W-30 oils have been found to have a *lower* viscosity than that of the base stock—to which had been added several per cent of an extremely viscous polymer solution!

As a matter of fact, it appears that ASTM extrapolated values are higher or lower than actual engine viscosities, depending on the V.I. improver used.

Fischl et al. point out that this variation is due to:

1. Differences in the low-shear viscosities of the V.I. improved oils not predicted by the ASTM chart.
2. Temporary viscosity loss in engine operation, which affects oils to varying degrees. (The term "temporary viscosity loss" refers to an apparent drop in the viscosity of polymer-thickened oils during the application of high shearing stresses to the oil. On release of the shearing stress, the oil reverts to its original viscosity.)

The authors have devised methods for estimating these two factors from viscosity measurements at 100 and 210 F. From these estimates they are then able to predict the engine viscosity during cold cranking of V.I. improved oils.

This method is as follows:

1. Estimation of low-temperature capillary (low-shear) viscosities: Based on a number of empirical formulas developed to accommodate the V.I. improvers used in their tests, they suggest the following equation for determining specific viscosity between 20 F and – 20 F (S_T):

$$S_T = \frac{S_{100}}{80 + T}\left(42\,\frac{(S_{100})^2}{S_{210}} + T + 28.2\right)$$

where:

S_{100} = Specific viscosity at 100 F
S_{210} = Specific viscosity at 210 F
T = Temperature between 20 F and – 20 F for which the specific viscosity S_T is wanted.

(The authors emphasize that this equation is of a preliminary nature and has not been tested extensively.)

Then the capillary viscosity of the V.I. improved oil is equal to the base oil viscosity (ASTM extrapolated value (multiplied by $(1 + S_T)$.

The authors point out that, since S_T is positive at all times, the calculated viscosity of the V.I. improved blend can never be calculated to be lower than that of the base oil. They feel that this provides a distinct advantage for the new method over the ASTM extrapolation technique for V.I. im-

Multigrade Oil Comparison

Multigrade oils are designed for satisfactory use over a wider range of operating temperatures than are single-grade oils. For instance, an SAE 5W-20 oil is like SAE 5W oil at 0 F and is like SAE 20 oil at 210 F. Similarly, an SAE 10W-30 oil is like SAE 10W oil at 0 F and like SAE 30 oil at 210 F.

Table 1—Engine Sensitivity to Oil Viscosity and V.I. Improvers
(from Wood)

Oil	Relative Oil Mileage		
	Car A	Car B	Car C
20	100	100	100
40	106	140	138
20W-40	131	128	140

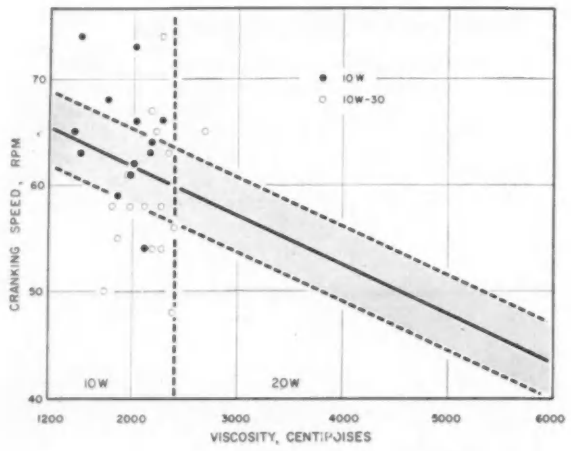


Fig. 4—Cranking speed versus viscosity determined by extrapolation (from Malone-Selby).

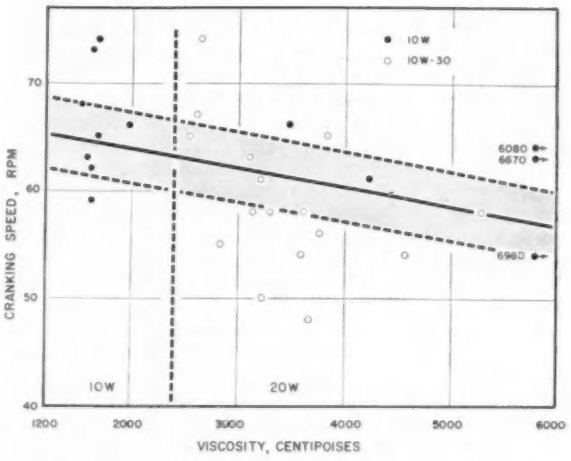


Fig. 6—Cranking speed versus viscosity determined by Fenske-Ostwald reverse-flow capillary viscometer (from Malone-Selby).

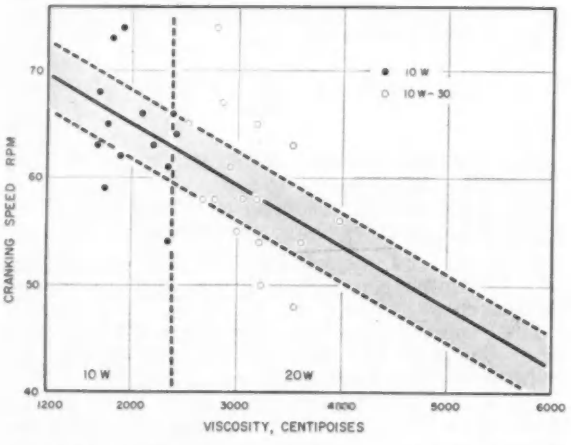


Fig. 5—Cranking speed versus viscosity determined by Brookfield viscometer (from Malone-Selby).

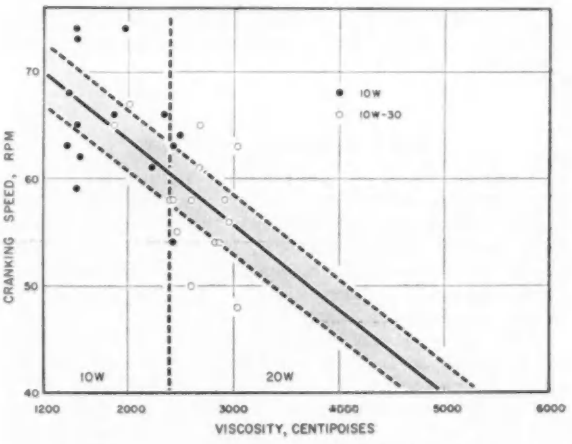


Fig. 7—Cranking speed versus viscosity determined by GM forced-ball viscometer (from Malone-Selby).

proved oils, and alone is probably sufficient justification for its use.

2. Extent of temporary viscosity loss in low-temperature engine cranking: As a first-order approximation for estimating the cold-starting performance of 10W-30 oils in the – 20 to 0 F range, they suggest that a 50% temporary viscosity loss due to polymer be used.

They point out that actually the temporary loss due to polymer depends on many factors, including:

1. Amount of viscosity that is contributed by the polymer at the given temperature.

2. Percentage of viscosity due to polymer that is lost as a result of shearing stress. (Traditionally, shearing rate has been used, but, the authors report, recent tests indicate that better correlation is obtained when shearing stress is used. Shear rate is a measure of the difference in velocity of layers of a moving liquid. Shearing stress is a measure of the force required to bring about this difference in velocity. Viscosity is the ratio of shearing stress to shear rate.)

3. Polymer type. (The commercial V.I. improvers currently available vary somewhat in their susceptibility to viscosity loss but are all of the same order of magnitude.)

4. Polymer molecular weight. (The amount of

viscosity loss at a given shear stress appears to be directly proportional to molecular weight.)

5. Polymer concentration. (The higher the concentration the lower the viscosity loss at a given shear stress.)

6. Temperature. (The variation of viscosity loss with temperature is slight, but the losses appear to be somewhat higher at low than at high temperatures.)

A study of the effects of these factors is now in process. When the work is completed, the authors feel that they will be able to predict the amount of temporary viscosity loss that occurs under any condition with any commercial V.I. improver blend.

While agreeing that the ASTM extrapolated viscosity is not a true indication of the starting performance of a multigrade oil, Malone-Selby approached the problem from a different standpoint. They compared the results obtained in a full-scale cranking study using commercial 10W and 10W-30 oils in cars at 0 F with low-temperature viscometric laboratory analyses. Briefly, their results are as follows:

1. When cranking speed is plotted against extrapolated viscosity, the points seem almost randomly dispersed, as shown in Fig. 4. By drawing the best straight line through the points (by the method of least squares) and calculating the correlation coefficient, it may be shown that the extrapolated values show only 5.3% correlation to the cranking speeds. This indicates that the viscosity of the oil at 0 F influences a cranking speed of, say, 50 rpm, by only 2–3 rpm——certainly a negligible effect, and contrary to experience. (The band shown in the illustration represents the standard deviation of points about the line.)

2. Cranking speed plotted against viscosity as determined by the Brookfield viscometer at 0 F is shown in Fig. 5. Drawing the best straight line through the points, the correlation between viscosity and cranking speed is found to be 32%. This says that 32% of the cranking speed variation is caused by the viscosity of the oil in the engine. This is certainly a much more significant effect than that indicated by the extrapolated values.

3. Cranking speed versus viscosity as determined by the Fenske-Ostwald reverse-flow capillary viscometer is shown in Fig. 6. More scatter is seen than with the Brookfield viscometer, since this instrument, when operated under its own hydrostatic head, is sensitive to structures which some oils form at 0 F. The correlation between these viscosity values and the cranking speed is found to be 16.3%. This is about half that of the Brookfield figure but about three times that indicated by the extrapolated values. Undoubtedly, this correlation would be improved by using a greater pressure to move the oil through the capillary than that developed by the hydrostatic head, since this would tend to eliminate the influence of fragile oil structures on the determined values.

4. Cranking speed versus viscosity as determined by the GM forced-ball viscometer is shown in Fig. 7. Correlation between these viscosity values and cranking speeds was found to be 43%, or about eight times better than that obtained from the extrapolation data.

In discussing this phase of the problem, Ware pointed out that a 5–10% dilution of the oil with gasoline will tend to eliminate the modest differences in startup that are found when different types of V.I. improvers are used. Since the crankcase of the average car that has been used for driving only short distances in cold weather will be loaded with gasoline, he feels that this should be taken into consideration somewhere along the line in the test work.

Flight Line Disruption . . .

. . . can be minimized by proper controls, education, and correcting troubles quickly at their source.

Based on report by **P. A. Schweich,** Lockheed Aircraft Corp.

CONTROL over design changes must be established if flight line activity disruption is to be lessened, and the responsibility for it rests with both manufacturing and engineering divisions. Engineering has the final decision regarding mandatory flight safety changes, but manufacturing must have control over the incorporation of the changes which may affect flight line operations. "Block" serialization coupled with "pilot" aircraft (one or more aircraft pulled ahead of normal schedule for production proving) provides an excellent opportunity to prove both engineering and manufacturing methods.

There are three basic types of changes—mandatory, necessary, and facility. The *mandatory* type, affecting flight safety or flight operations, must be made prior to the next flight and may require extensive modification on the flight line. Here, modification planning can be of great help.

Necessary change is one made in an expedited manner to achieve fulfillment of the aircraft mission. If the change is to be made effective during the flight span, authorization and responsibility must be delegated to a change board on which both engineering and manufacturing have a voice.

The *facility* change generally provides savings in

man-hours, material, tooling, facilities, or equipment. It should not upset schedules or operations. Savings thought justifiable are frequently not really justifiable when the cost of disruption or broken schedules are deducted.

Education Is Necessary

Education of flight line supervision may be necessary to overcome resistance to mandatory and necessary changes. Cooperation of flight line supervision requires some knowledge of sales, engineering, fabrication, material, scheduling, and planning. Personal contact with representatives of each department is helpful in instilling a desire to take the direct approach on the flight line.

The liaison engineer has the responsibility for detecting engineering errors. He must be trained and instructed to circulate in assembly and flight departments and to take the initiative to institute changes or force explanation from those responsible for difficulties. He should have a system of documentation that will permit immediate action.

Flight line supervision and personnel must be willing to take the responsibility of stopping flight line operations upon indication of hazardous conditions even though inspection and engineering have not yet been informed. An evaluated opinion is then obtained from the project engineer prior to flight release.

Transmission of Data

The transmitting of data obtained by engineering flight organizations during the development of first articles to project engineering or manufacturing could be vastly improved. Too often, the unsatisfactory conditions observed by engineering flight personnel are corrected on one airplane and not on subsequent units.

One concern overcomes this by assigning one capable engineer to each unit or series of units to evaluate and report discrepancies or malfunctions to the project engineer. Generally speaking, the engineer should report to the organization most interested in corrective action.

Most will agree that the flight line foreman is most affected by airplane schedule since there is no organization beyond his to complete and deliver the airplane. For this reason, rapid correction of design troubles in early production units is mandatory. The personnel of all organizations servicing the flight department should be as conscious of the daily schedule as the foreman of flight line, and flight line supervision should drill others to accept responsibility for action as part of a team.

Flight Checkout

Reduction in the number of flights required to complete flight checkout depends primarily on quality. Correct sequencing during preflight operations and on the flight line can help in developing quality. The positive approach to preflight sequencing will reveal that,

1. The majority of operations fall into well defined categories.

2. Practically all of this work can be stationized.

3. Flight mechanics can be especially trained to perform rework operations of a non-standard type as well as standard operations.

To achieve maximum economy in the operation of a flight line it is often necessary to locate the flight base away from the assembly plant to insure proper climatic conditions. Some companies prefer making the first production flight in conjunction with the ferry flight to the remote base. Others choose to ship major structural components to a final assembly and flight base. There are these advantages to the latter method:

1. It is seldom necessary to perform preflight signout operations more than once per flight due to weather and as a result there can be better sequencing prior to flight.

2. It is unnecessary to retain extra personnel, or pay premium overtime rates, to level the production schedule after long weather delays.

3. In-process flight line inventory can be cut to a minimum with elimination of a weather pool.

(This article is based on the secretary's report of panel on "Engineering and Manufacturing Look at Flight Line Operation" held at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 11, 1955. This report together with 14 other panel reports are available as SP-313 from SAE Special Publications Department. Price: $2.00 to members, $4.00 to nonmembers.)

Serving on the panel which developed the information in this article were:

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Forgings made from "exotic" alloys have extra-special properties. They require extra-special care in preparation, too.

Forging Super Alloys

E. Foley, Ladish Co.

Based on the secretary's report of the panel on "Forging of Rare Metals" at the SAE 1956 Production Meeting and Forum, Cleveland, March 19, 1956.

TO PRODUCE high quality, super alloy forgings with uniform properties throughout, melting and heating techniques must be controlled with precision. If all gases can be eliminated from the alloy during melting, highly reactive elements—such as titanium and aluminum—can be added without forming oxides which weaken it. The addition of these metals or other scarce materials such as zirconium, molybdenum, and nickel, produce stronger alloys that are able to withstand the high temperatures of many modern applications.

Nickel alloy forgings . . .

Forgings made of nickel base alloys have great strength and corrosion resistance at high temperatures.

One company uses both electric arc and high frequency induction furnaces to melt ingots weighing 500 to 20,000 lb. Certain alloy ingots may be cooled to room temperature, conditioned, and then reheated to forging temperature. Other alloys must be stripped hot and charged directly into a furnace at forging temperatures to avoid damage to the ingot during cooling.

Fuels used in heating must not contain much sulfur because high nickel alloys are susceptible to intercrystalline attack. Gaseous fuel should not contain more than 30 grains of sulfur per 100 cu ft. Oil, such as ASTM #1 and 2, is safe provided sulfur does not exceed 0.5%. Coal or coke is generally unsatisfactory.

The atmosphere in the heating furnace should have 2% or more carbon monoxide for reduction purposes. A strongly oxidizing atmosphere is undesirable. Furnace atmosphere that fluctuates from oxidizing to reducing causes intergranular attack resulting in surface cracking during hot working.

The furnace hearth must be kept clean to achieve high alloy quality during heating. Slag, scale, and other contaminants usually contain sulfur. Baffles must be used to prevent the impingement of flame and unburned fuel oil on the alloy.

Since each melt has different forging characteristics it must be sampled and tested for bend and compression at various temperatures. Alloys should be heated to a temperature about 150 F below the top bend temperature. Furnace temperature very much higher than the desired heating temperature may cause overheating and nonuniformity.

For best forging results the following rules are recommended:

★ Start forging with as little delay as possible after heating.

★ Forge within the specified temperature range.
★ Use heavier blows at first. Decrease force of the blows as the temperature drops.
★ Rate of reduction should be such that temperature is maintained or decreased slowly. Fast forging with highly localized rate of reduction may increase the alloy temperature until it burns and becomes permanently damaged.
★ When forging bars, forge uniformily across the entire length keeping a uniform cross section.
★ When forging small parts, such as turbine buckets, stay within the narrow temperature range of the bucket alloy (1950 to 2200 F). If temperature drops below 1950 F during forging, the metal may develop stresses that cannot be removed with standard heat treatment.

Titanium alloy forgings . . .

Consumable electrode melting and double melting at reduced pressure are providing homogenous titanium ingots with little segregation. Interstitial elements, such as hydrogen, can be controlled comparatively easily.

When heating titanium, an oxidizing atmosphere should be used. A reducing atmosphere will cause hydrogen contamination.

In 1956 about 10,000,000 lb of titanium and titanium base alloys will be produced. About 5,000,000 lb will be forged into compressor blades, wheels, spacers, rings, and air frame parts.

One of the biggest problems in the economical use of titanium is how to reclaim scrap. It is extremely difficult to sort the different alloys, remove broken carbide bits, and prevent gas contamination in titanium scrap.

Molybdenum alloy forgings . . .

Molybdenum and molybdenum alloys are melted by the consumable electrode process. Molybdenum structure is very coarse with $\frac{1}{4} \times 2$ in. crystals developed in 6 in. diameter ingots.

Furnaces used in heating molybdenum must be capable of reaching 3000 F. Since molybdenum oxidizes readily there is no problem with scale. Once a wrought structure has been developed, the metal can be forged into bars, forged in closed dies, drawn into wire, and rolled into sheet.

Molybdenum is difficult to deform. At 2200 F its hardness is equivalent to that of iron at 800 F. When strain-hardened by forging its hardness at 2200 F equals that of iron at room temperature.

Molybdenum cannot be cast to shape. Currently known alloys do not respond to heat-treatment.

Ingot yield can be increased from 50% when using conventional forging to 83% when using the Sejournet extrusion process.

Molybdenum alloys containing up to 1% niobium or titanium have shown 100 hr stress rupture strength of 63,000 psi at 1800 F and 50,000 psi at 2000 F.

Zirconium alloy forgings . . .

Zirconium and its alloys are used almost exclusively in the nuclear energy field. Currently annual ingot production is 250,000 lb. By 1958, production is expected to be over 2,250,000 lb. During this period the price is expected to decrease from $18 per lb to $10 per lb.

Zirconium has been used unalloyed although an alloy known as Zircalloy 2 (containing 1½% tin) has also been widely used.

Zircalloy ingots can be forged by hammer or press. Closed dies normally used for ferrous alloys can be used to forge zirconium with only minor modifications.

Zirconium is produced by the consumable electrode melting process in much the same manner as titanium.

It is forged readily in the 1600–1800 F range. Above 1600 F the metal is body centered cubic. Below 1600 F it reverts to the hexagonal, close-packed structure which is difficult to deform by hot working.

Heating requirements are similar to those for titanium. The furnace should be clean and flame impingement should be avoided. Contamination by atmospheric gases should be prevented. Oxygen and nitrogen increase hardness and strength, but decrease elongation. Hydrogen causes embrittlement.

(The report on which this article is based is available in full, together with reports of six other panel sessions of the SAE National Production Meeting and Forum held in Cleveland, March 19, 1956. This publication SP-314, is available from the SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

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Based on the secretary's report of panel "Powerplant Installations and Components" which was held as part of the SAE Golden Anniversary Aeronautic Production Forum, Los Angeles, Oct. 12, 1955.

Jet Engine Servicing Gets More Complicated

As jet engines become more complex, servicing and operational problems also become more complex. Here are some current problems and what's being done to solve them:

Debris damage . . .

. . . cost the Air Force $18,000,000 in 1953 and 70 major accidents in 1953 and 1954. Here's what's being done to prevent foreign object ingestion in jet engines. →

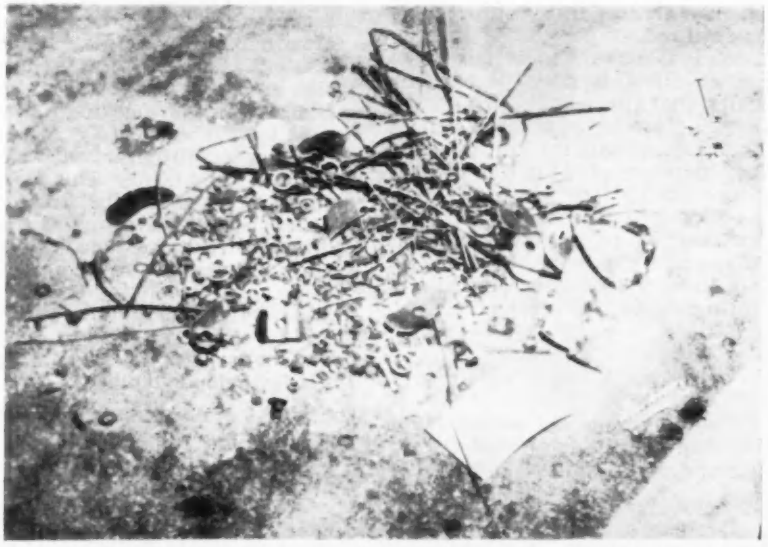

Fig. 1—Nine lb of scrap metal pieces were collected during a run-up and take-off area sweeping. This debris may be blown into a jet engine damaging compressor blading and other engine parts.

INITIAL attempts to protect jet engines from debris included fixed and retractable screens within the duct or engine. But damage due to the screens themselves, performance losses, and the tendency of the screens to collect ice have put them in disfavor. Present protection methods are combinations of the following:

1. Portable run-up screens of ¼-in. mesh which are attached to the duct inlet whenever the engines are run up by ground crew.
2. Taxi screens, usually of a finer mesh, which are kept on the duct inlet until just prior to the take-off run.
3. Better housekeeping of run-up and take-off area by sweepers to remove debris that might be blown into the inlet. Fig. 1 shows results of such cleaning.
4. Better inspection of duct interiors prior to engine operation.

The tendency of mechanics to overlook or leave objects in ducts is very hard to control. The use of duct plugs helps in two ways: (1) Sealed plugs installed on the production line after thorough inspection by Quality Control, and which can be removed and rein-

stalled only under Quality Control supervision, prevent objects being left in the duct. (2) The use of plugs on the flight line prevents airborne dirt and weather damage.

Experience has indicated that 20 mesh screen will restrict particles to a size that will not nick blades. However, some engines may be so sensitive to damage as to require 20 to 12 mesh, while ½-in. mesh may be satisfactory for more hardy engines. For example, long compressor blades tend to bend when damaged but stay with the engine, whereas, short blades usually shear off. The use of screens while running engines for adjustment purposes requires performance compensation. Some companies have two sets of checkout references, one with screens and one without.

The problems associated with run-up area sweeping include:

1. Air traffic may be tied up while runways are being swept unless more than one runway is available. A sweeper requiring only one pass is desirable.
2. Wind can blow debris back into the area after sweeping. One way of controlling this is to plant trees parallel to the runway.

All evidence indicates that engines do not pick up debris off of the ground. Damage is caused by wind or exhaust blasts blowing material at and into the ducts. This appears, therefore, to be more of a problem with military aircraft which may be grouped for simultaneous take-off than with commercial planes which usually take-off alone.

Air inlet ducts . . .

. . . must be designed clean and matched carefully with the engine or else a pressure pattern distortion may reduce thrust up to 5%.

DUE to the large effect that the air inlet duct has on engine performance, the duct design is becoming more and more important. The penalty in poor design or workmanship can be quite large. For example, with a turbojet engine, 1% loss in recovery can mean an indirect 3 to 4% increase in drag. A similar loss with a turboprop can require almost 400 lb more fuel consumption per hr. Consequently designing ducts to give best performance is more important than eliminating duct weight.

Aerodynamic Smoothness

Since internal airflow is in the high subsonic range, aerodynamic smoothness is as important inside the duct as outside the airplane. Flushness tolerances in the order of 0.030 in. maximum deviation from contour on 6 in. centers, 0.020 in. on 4 in. centers, and 0.005 in. on 2 in. centers are sometimes called for. Where transverse butt joints are necessary in the inlet, a difference in joint flushness of 0.003 in. can be excessive, although aft of the inlet and inside the duct, 0.015 in. can often be allowed.

Air leakage must be kept to a minimum and duct joints sealed in such a way that relative working will not occur. The use of sealing methods similar to that employed for fuel tanks is one ideal method of duct fabrication. The use of non-permanent type connectors such as bolts and quick-fasteners within the duct should be kept to an absolute minimum to avoid the possibility of their working loose and damaging the engine. Where their use is necessary, positive method of retention and good quality control in manufacturing is required.

Although heavy materials make better ducts, it must be remembered that the duct surface area is large. For one airplane, 0.001 in. increase in wall thickness means an increase of 1 lb in weight. Since such ducts are quite rigid and fixed, it frequently aids production to separate the duct from the basic airplane, so that the two are independent and relative adjustments can be made.

Design Principles

The following are examples of existing duct design principles for specific problems:

1. In a duct used on a turbojet trainer, satisfactory stiffness is obtained by riveting the inner skin to an outer beaded skin and making the entire assembly an integrated part of the airplane structure. This method has the undesirable features of requiring a large number of rivets which can cause local roughness. The inner skin tends to conform to the beaded outer skin. Too, cracks are possible between stiffeners. As a result of these features and its integrated nature, close tolerances are not feasible.
2. Another duct is used on a high performance turbojet fighter where high duct performance is necessary. The wall is made from integrally stiffened, extruded cylinders which are split and formed to shape. The seams at the end of the stiffeners are joined by a heavy angle, sections are butted, and the entire assembly supported from the airframe structure. Waviness tolerances of 0.005 in. on 2 in. centers are practical with high caliber tooling. This is an example where plastic or cast ducts could be used to give the highest degree of smoothness and adherence to contour. However, it is believed that the integrity of plastic ducts is not proven and some form of nondestructive testing is required to insure dependability.
3. Another example is a duct used on a turboprop transport. Although the duct is short, its requirements include close adherence to smoothness and contour, fireproof characteristics, the ability to take up to 10 psi pressure from certain

flight conditions or minor explosions, complete de-icing throughout its length, ease of replaceability, and flexibility due to relative motion of engine cowl. This duct has fore-and-aft joints and is made of corrosion resistant steel sheet with circumferential stiffeners spotwelded on the outside. In a marriage of design and production requirements, Class A spotwelds are used on the inside and Class B spotwelds on the outside.

Opinions differ as to whether it is more desirable to have the inlet lip transverse joint on the outside or inside of the duct, but there is general agreement that:

1. Accessories should be kept off the nose of the engine insofar as possible to prevent the necessity of access into the duct.
2. Internal screens in duct or engine are undesirable.
3. A close tolerance on the inside of the engine inlet is necessary to eliminate a step at the duct-engine connection.
4. Excellent tooling is necessary to assist the shop in holding engineering requirements.
5. Duct design should be such as to minimize pressure variation at engine inlet.

Fluid line fittings . . .

. . . can create as many problems as they solve. Watch out for self-sealing, quick disconnect fittings, standard flare-type AN fittings, and fuel filters.

AFTER self-sealing, quick-disconnect fittings were proven successful in aircraft hydraulic systems, their use quickly spread to other fluid systems. However, lack of sufficient consideration of the intended purpose often led to poor applications and sometimes accidents resulted.

Their most advantageous feature is their self-sealing rather than their quick-disconnect ability. This is because more time is saved due to the elimination of bleeding or functional checks than in the actual disconnecting operation. In a typical pod-type engine:

Total time required to replace engine—	25 min
Time saved by quick-disconnect features on fluid lines—	75 sec
Time saved not having to retest hydraulic system—	60 min
Time saved not having to drain fluid lines—	6 min

The time saved by not having to bleed or recheck the hydraulic system represents a large portion of the installation time and makes the self-healing feature desirable. There are other disadvantages of fittings with quick-disconnect features:

1. They are not reliable. (Many accidents have been attributed to them.)
2. Various types operate differently. They are tricky, require careful handling, and personnel must be trained to use them correctly.
3. They are comprised of 15 to 30 parts. (Assembling these parts is costly.)
4. Because of the quick-disconnect feature, a coupling is frequently installed in closely confined areas.
5. No weight is saved by the feature.

Thus, it is evident that rather than try several types of quick-disconnect fittings when trouble develops, it may be better to avoid quick-disconnect fittings altogether.

Another problem frequently en-

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(The report on which this article is based, together with reports of 15 other panels of the SAE Golden Anniversary Aeronautic Production Forum, Los Angeles, Oct. 12, 1955, comprises publication SP-313. It is available at $2.00 to members; $4.00 to nonmembers. Write: SAE Special Publications Department.

countered in plumbing systems is the tendency of the standard flare-type AN fitting to leak in cold weather, whereas in standard conditions it functions satisfactorily. Since the parts making up the joint can be of the same material, it would appear logical to assume that it would contract and expand uniformly. It apparently does not. An analysis of the situation suggests the following possibilities:

1. Perhaps the unannealed flared portion of the tube is annealing and relaxing due to repeated cold soaks. This could be eliminated by annealing after flaring.

2. The use of an aluminum nut and fitting with a steel line and sleeve will give a contraction coefficient relationship that will tighten the joint in cold conditions. The use of titanium for the fitting in the above combination will give even better sealing characteristics.

3. High frequency vibration may be a factor for it has been proven that in certain areas lock wiring is required to insure a tight connection on all styles of friction-locked fittings.

Another problem is fuel flow blockage due to ice crystal accumulation, and the inadequacy of filters to handle certain extreme filtering situations. JP-4 fuel will carry more water in suspension than gasoline. One test with JP-4 fuel from a new barrel cooled to - 65 F caused a complete fuel stoppage in 15 sec because of ice accumulation on the pump screen. Other tests have shown that fuel filters on F-86 airplanes operating in Korea have been blocked after 60 sec operation due to dust accumulation. Fuel filters can be used but they:

1. Are an additional maintenance problem over that required by the engine filter.
2. Are another leakage source.
3. Add considerable weight.
4. Represent a fire hazard due to servicing spillage.
5. Take up valuable space.
6. When plugged, their bypass will allow contaminated flow.
7. Give a false sense of security.

One suggestion for the reduction in the ice blockage problem is to use a large area screen between the boost pump and the rest of the fuel tank in lieu of the present small area screens. Eliminating the filter from the airframe fuel system and more frequent servicing of the engine filter might be a better method. The engine filter is located in an area frequently serviced and protected from the possibility of fire.

The above analyses are examples of today's situation where much equipment is specified and used without giving careful consideration to its usefulness or purpose. Improvement of production and maintenance is possible if this is done early in the airplane's design stage.

Some of the other problems connected with fluid line fittings are:

1. The pressure loss through self-sealing couplings is usually too high, although there are fittings on the market designed to have no appreciable pressure drop.

2. Nearly all self-sealing couplings allow a small amount of air in the line. Most systems, especially engine fuel controls, can accommodate this.

3. Electrolytic corrosion can occur at joints composed of different types of metals.

4. The use of a dry lube (graphite or moly-sulfide coating) has been successful in some cases in preventing corrosion in fitting assemblies. This treatment is not consistent enough for dependable use.

Engine removal . . .

. . . after installation, is costly and sometimes can be prevented. Here are suggestions to eliminate unnecessary removal.

ONCE an engine has been installed and checked out in an aircraft it should not have to be removed. The most common causes of removal and what can be done to decrease them are:

Fluid line leaks. This may be cured by a close torque check of all fittings prior to installation and making pressure checks of the systems prior to installation.

Component or accessory failure. A thorough pre-installation detail check should help in this case.

Excessive engine vibration. Frequently, the pilot's opinion of excessive vibration is not borne out by a later engine check. In one case, such "squawks" were greatly reduced by building a test seat which could reproduce the vibration observed by the pilot in the airplane. By comparing this vibration with that which would be produced by an engine excessively out of balance, the pilot would frequently change his opinion. This simulation can also be used to educate the pilot as to the type of vibration caused by engine-airframe rub and burner roughness, and allow him to identify these problems during airplane flight.

Overhauled engines not brought up to the latest Technical Order modifications. This requires close inspection of both records and engines to insure compliance. It has been found helpful to have the engine manufacturer campaign such engines prior to delivery.

Lack of correlation of performance checks between the airframe and engine manufacturer. To eliminate this requires close coordination and understanding between the two parties and education of the inspectors.

Other Suggestions

Other suggestions which can eliminate unnecessary engine removals include: check engine in test cell before installation. In some cases, between 100 and 200 engines of each new basic design are checked out prior to their installation. Other companies, however, have not found it necessary to go to this extent.

Periodically inspect an engine (for example, every tenth one) for discrepancies and errors and coordinate the findings with the engine manufacturer.

Run complete continuity and resistance checks prior to installation.

The Truth About Tires

What is a tire's "ply rating"?

Are nylon cord tires better than rayon?

Why don't we use larger tires?

How are Tire and Rim ratings established?

Is dynamic balancing really necessary?

Will deflation give better traction?

Can tires be overloaded safely?

How safe are tubeless tires?

What inflation pressure should you use?

How good are steel cord tires?

A. W. Bull, U. S. Rubber Co.

W. E. Shively, Goodyear Tire & Rubber Co.

Based on a report of a panel discussion "Rubber on Wheels" presented at a meeting of the SAE Montreal Section, May 16, 1955. The panel moderator was Paul Lamoureux, Trans-Canada Air Lines.

At an SAE Montreal Section meeting, two experts gave frank answers to questions about tubeless tires, safety, inflation pressures, strength ratings, and new materials.

How safe are tubeless tires?

Tubeless tires give added insurance against sudden blowout. In a tire with a tube, the tube may blow itself out through a carcass rupture and burst, giving instantaneous deflation and making the car difficult to control. The tubeless tire leaks air through the rupture letting the tire down slowly.

There are some types of safety tubes which are made of additional plies of strong material and it is almost impossible for these safety tubes to blow out.

Other safety tubes have an inner diaphragm which supports the weight of the car if the outer tube and tire rupture and lose air. It should be remembered, in any case, tire failure is the cause of less than 2% of fatal accidents.

Are tubeless tires better than tires with tubes?

Most tire manufacturers don't expect tread mileage of tubeless tires to be better than conventional tires. The tubeless should run somewhat cooler. This should improve tread life, but it isn't a major factor. (There hasn't been enough experience for accurate mileage data, yet.)

The tubeless tire can be re-capped no more easily or difficultly than the conventional tire.

The lighter weight of the tubeless makes it desirable for aircraft.

The tubeless tire is no more difficult to repair than a conventional tire if manufacturer's instructions are followed. Of course, with a severe rupture you can't just put a boot in it and run it with a patched tube as with the conventional. A complete repair job is necessary to re-establish the air holding capacity of the inner layer.

A tubeless tire that wears beyond the stage where

it can be repaired by normal procedures may have its use extended by putting a tube in it. The heavy ridges inside a tubeless tire are not likely to chafe through the tube. The ridges are put there so that during manufacture air inside the tire can escape around the bead. The ridges do not affect tire life.

A tubeless tire that is punctured with a nail will usually retain enough air to reach a service station. Some tubeless tires have been run hundreds of miles with nails in them before going flat. Running with a nail in the carcass is liable to cause additional damage.

Tubeless tires were adopted partly to take advantage of savings in manufacturing costs. Assembly lines, using automatic mounting methods, can mount thousands of tires a day with fewer laborers. In the future costs will be lowered even more; however, at present it costs just as much to make a tubeless tire as a tire and tube.

Although it is true some tube problems are eliminated by doing away with a tube, most tube problems concerned the valve and the new tubeless tires also have valves.

Why don't we use larger tires?

About 35 yr ago we used to have larger tires on the front wheels to support the unequal distribution of load. But nobody wanted to carry two spare tires. Today the average front wheel tire is 20% overloaded because the car manufacturer saves money by putting on the smallest tire possible. The Tire and Rim Association can only recommend tire size. It has no legal status which can force car engineers to use its standards.

What inflation pressure should you use?

Use the inflation pressure that the manufacturer recommends. These pressures have been designated to give satisfactory mileage, good riding comfort, and stability.

It is true that if you put 28 psi into a tire recommended for 24 psi you will decrease the tread wear slightly and increase tire mileage. However, you will sacrifice riding comfort. Too, the gain in tread wear may be offset by increase in bruises and tire breaks. A tire that is over-inflated is more susceptible to rupture than one which is at rated pressure.

If you are driving on bad roads and wish to soften the effect of bumps on the car, you may wish to reduce pressure slightly. Reducing pressure a few pounds will give better traction in soft sand because the tire print will be larger and the car won't sink so far into the sand.

If you are driving at high speeds on smooth roads for long distances you may want to increase tire pressure to about 30 psi. Contrary to popular opinion, high speed driving does not automatically increase tire pressure appreciably. By slightly overinflating, you help the tire withstand "standing wave" which causes the tire to flex excessively, heat up, and deteriorate.

Most new cars have higher inflation pressures recommended for front than for rear tires because with a three-passenger, normal load about 54% of the total weight is in the front and 46% in the rear. If you intend to carry extra passengers and luggage in the rear you may wish to raise the rear tires about 2 or 3 psi.

Truck and bus tire pressure has to be high enough to support the vehicle at its heaviest load. However, when running empty, pressure should be reduced to soften the ride. If a tire has too much pressure for the load it's carrying, the bearing pressure on the road is in a very narrow zone down the center of the tire. Heat builds up in that zone and the tread may separate from the carcass. A lower tire pressure will distribute the load over the surface of the tire.

Are nylon tires better than rayon?

Nylon cord tires resist bruise breaks and fatigue failure better than rayon tires. However, they cost more. When inflated they tend to stretch more than a comparable rayon tire does. The nylon tire will continue to grow slightly larger for the first 10,000 miles. As a result, the outside of the tire is subjected to strains and groove cracking. Too, a nylon tire wears its tread faster than a rayon tire. In the wintertime nylon tires tend to develop flat spots if the car stands still for some time. The tire will then bump for a few miles until it works itself out. There is no permanent damage.

Nylon tires are slightly noisier than rayon tires.

Some nylon tires can take more re-caps than rayon tires. Under high heat, speed, or loads, the heavier tread rayon tire might give trouble, whereas the nylon tire may have several re-caps before it wears out.

In truck and bus service, nylon tires probably cost less per mile. For off-the-road work, the extra strength of the nylon and its greater resistance to bruising and rupture is advantageous.

For passenger cars, very few nylon tires ever blow out. A four-ply nylon tire gives better service, softer ride, and cooler running than a six-ply rayon tire.

As long as nylon is comparatively more expensive than rayon, there will always be a market for rayon tires.

Should sealants be used in tubeless tires?

Most new cars do not have sealants in the tubeless tires because automobile engineers decided that they don't need it.

The puncture resisting ability of a tire with sealing material in it is no different than one without it. The only advantage is if a nail is pulled out, the soft sticky sealant may flow into and plug the hole, thus making additional repairs unnecessary. A disadvantage of a sealant is the added weight and

susceptibility to increased heat. Sealants tend to drift at high temperatures during fast driving and flow toward the crown of the tire.

Small punctures in the tubeless tire can be repaired easily by stuffing the hole with sealant from the outside. Many repairs can be made without removing the tire from the wheel. If the nail is large or the damage extensive, a vulcanized patch on the inside may be necessary.

Can tires be overloaded safely?

If a normal truck tire is overloaded about 20% it will still be fairly safe for normal service. But if you intend to drive at high speeds you'd better not overload too much.

The more tires are overloaded, the less life they have. Tread wears faster and the carcass becomes more susceptible to failure. Of course, it may be more economical in some cases to carry a large overload on over-inflated tires even though the tire wears out a few thousand miles sooner.

It's dangerous to overload a heavy tread tire as much as you might overload a normal tread tire. Probably nylon cord tires can stand more overload longer than comparable rayon tires.

Passenger cars can take about 20% overload without too much depreciation in tire life if they are run at moderate speeds.

Is dynamic balancing really necessary?

Dynamic balance—or static balance, for that matter—is not much of a factor in tire life. Some unscrupulous service companies have made balancing a racket. But tire wear is not affected very much by lack of balance.

Of course, if there is excessive shake at high speeds, a dynamic balance or static balance may be necessary to get rid of it. However, the average automobile with modern tires needs nothing more than static balancing.

Most aircraft and truck operators, too, have found that dynamic balancing is unnecessary.

Most passenger car tire manufacturers supply tires already balanced within 20 oz-in. For large tires, such as truck and aircraft, permissible unbalance may be much greater because it is a smaller portion of the total mass. Truck tires rarely give trouble even at 100 oz-in. unbalance.

What is ply rating?

The ply rating of a tire is a measure of what its manufacturer says its strength is. The actual number of plies on the tire may vary, depending upon the cord material which is used. For instance, one manufacturer may make a tire with 10 plies of cotton; another may make a tire equally strong of eight rayon plies; another may make a tire with four plies of steel wire. These three tires of equal load-carrying ability would be rated 10-ply—the rating of the equivalent cotton tire.

Since the number of plies varies with the materials the plies are made of, the number of cords per inch, and other factors, the yardstick for the rating is the strength of the conventional cotton cord tire.

A 12-ply rating tire has a higher load carrying ability than a 10-ply rating tire.

There is no official body which checks a manufacturer's rating claim. The Tire and Rim Association feels a fraudulent claim eventually will be discovered by the public.

How are Tire and Rim Ratings established?

The Tire and Rim Association is a trade organization comprised of representatives of tire companies and wheel manufacturers. It sets up standards for dimensions, loads, and weights so that tires made by any company will fit the rims that are made by any other company. It also establishes load ratings, inflation pressures, and other important factors in the servicing of tires.

These standards are based on the accumulated experience of Tire and Rim Association members who have access to information obtained in laboratory and road tests conducted by member companies. The ratings are continually modified to keep pace with new designs, materials, and construction.

The Tire and Rim Association is supported by industry. Its only connections with government are cooperative technical advisory committees which help the government establish standards.

Subcommittee task forces are assigned a problem to study. They may recommend industry practices which are reviewed by a Standards Committee composed of the four principal tire companies, the three large rim and wheel manufacturers, and two smaller companies. To establish a Standard requires a unanimous approval of the Standards Committee and approval by the Association membership as a whole. An "experimental practice" can be established by six votes of the nine-man Standards Committee.

How good are steel cord tires?

Wire cord tires are still too expensive to be adopted on a large scale in the United States and Canada. Michelin, in France, has been successful because it produces its own fine wire. Michelin's labor costs and cost of finished wire are less than half what companies here would have to pay.

Firestone and others on this side of the Atlantic are making some wire tires. A four-ply wire tire is stronger than a 12-ply rayon or nylon tire. It also costs more. One disadvantage is that a wire tire has to be run at higher inflation pressures to prevent flexing, which causes fatigue failures in the wire.

The Automotive Safety Engineer —and Company Policies

Roy Haeusler, Chrysler Corp.

Excerpts from paper "Automotive Safety Engineer" presented at SAE Pittsburgh Section, Feb. 28, 1956.

AN automotive safety engineer in a large automobile company covers a wide range of activities—each related to establishment and carrying out of his company's safety policies.

He spends considerable time dealing with the engineering division. But he deals also with public relations, sales, advertising, production, and service activities of his corporation.

At Chrysler he's concerned with all the major elements of the Corporation's established policy regarding automotive safety. Chrysler policy is to:

1. Continue formulation and development of Corporation policy on safety of automotive products;
2. Provide all practical safety features that appear likely to reduce the driver's probability of having an accident—or to reduce the severity of injury should an accident occur;
3. Provide additional safety features as soon as they can be properly developed and prepared for production;
4. Work closely with the medical profession, with traffic enforcement and motor vehicle administration personnel, with insurance company officials, with legislators, and with educational and research groups;
5. Give careful, sympathetic, and respectful consideration of all safety suggestions;
6. Exchange safety information with other automobile and parts manufacturers;
7. Provide the widest possible circulation of safety information that will aid in the establishment of good driving practices and good maintenance practices;
8. Provide aid and support for independent safety research programs.

Continuing formulation and development of Chrysler Corporation policy concerning the safety of its automotive products is intended to provide an acceptable safety policy in the eyes of the outside world, a policy that reflects the willingness of the Corporation to take whatever practical steps are within its power to take, as part of a nation-wide effort to reduce the highway traffic toll.

It is also intended to result in a clearer understanding and consequently in closer agreement on our safety policy on the part of those within the Corporation, especially those at management levels who have responsibility for its execution.

Chrysler's policy, so formulated, is to give prime attention to the safety factor in all Chrysler Corporation automotive design, development, and production and thus to provide the highest degree of transportation safety possible, consistent with the manner of usage of our vehicles by the driving public. This means giving adequate attention not only to such special safety features as safety belts and instrument panel pads, but also to all other components of the vehicle, all the way from the tires to the roof.

We are concerned with such matters as the location of transmission controls. Our new push button controls have been located to the left of the steering

wheel in order to insure freedom from interference by other occupants of the car, particularly children. We are concerned with greater vehicle responsiveness. We are equally concerned with the ability to decelerate the vehicle. The automotive safety engineer is concerned with the entire car and with all its components, not just with a few safety accessories.

The second major element is to provide all practical safety features that appear likely to reduce the driver's probability of having an accident or to reduce the likelihood or the severity of injury should an accident occur.

True "Safety" Device Increases Net Safety

By practical safety features we mean those that are likely to be accepted, used, and appreciated by the driving and riding public. When we consider the possibility of offering shoulder harness, for example, we must face the fact that shoulder harness is less convenient to use than the lap type of seat belt and it is only natural that a smaller segment of the public is likely to accept it.

When we speak of practical safety features we also imply that the increase in safety must be a net increase. In other words, any inconvenience or added complexity must be appreciably outweighed by added safety. We must be reasonably sure that the items proposed as safety features do not add new major hazards which outweigh any possible gain in safety. For example, governors such as might be used to limit car speed might actually be a new source of danger since they would interfere with a vehicle's responsiveness at a time when it might be very urgently needed. The type of restraint called a "crash bar" is another example of a type of device that could introduce new and serious hazards. Col. John Paul Stapp of the U. S. Air Force and others have shown through their researches on human tolerance to deceleration that it is extremely important that the restraint be applied across the proper areas of the body and in the proper direction if the restraint itself is not to produce serious injuries of its own.

Chrysler Works Closely with Safety Groups

Determination to provide additional safety features as soon as they can be properly developed and prepared for production is another policy element. Safety is too important to wait for model changes.

Determination to work closely with the medical profession, with traffic enforcement and motor vehicle administration personnel, with insurance company officials, with legislators, and with educational and research groups, in order to get maximum benefit from free interchange of experiences and information is also a major element. This means specifically:

- Participating in meetings of the American Medical Association and other doctors' and surgeons' societies,
- Attending meetings of the American Association of Motor Vehicle Administrators and their committees on engineering and inspection,
- Entering into formal discussions with insurance company executives, particularly to discuss public information and educational programs,
- Reading and studying all the various legislative proposals appearing currently in the many state legislatures now in session,
- Attending legislative committee hearings and providing comment and explanation at the professional level, especially regarding the engineering and production problems that may be engendered by the proposed legislation and the cost penalty with which the ultimate consumer may be faced if such a cost penalty is involved.

Chrysler safety policy also includes the careful, sympathetic, and respectful consideration of all safety suggestions of all kinds from the driving public generally and from members of especially interested professional groups such as safety engineers and from doctors and surgeons. Many of these involve extremely complicated apparatus and mechanisms of highly questionable practical value to say nothing of the prohibitive cost which would attend their production. There are those who tell us the engine must be in the rear of the car and others who assure us that such a car cannot possibly be as safe as the design we now call conventional. Many of these suggestions appear over and over again, sometimes in slightly different form, sometimes in virtually the same form as before. Each such suggestion is dealt with in a careful and considerate manner but only after a prescribed understanding has been reached between the Corporation and the person making the suggestion.

In Safety, It's Cooperation, Not Competition

A sixth major element of Chrysler's safety policy is the exchange of safety information with other automobile and parts manufacturers in order that all vehicles may benefit. This exchange of information occurs through the committees of the Society of Automotive Engineers, the Automobile Manufacturers Association, and other organizations and is also carried on directly.

A seventh major element of our safety policy is the determination to provide the widest possible circulation of safety information that will aid in the establishment of good driving practices and good maintenance practices.

The eighth and final element of the safety policy is the provision of aid and support for independent safety research programs such as the Cornell University Medical College Automotive Crash Injury Research Project, and the various projects of the Automotive Safety Foundation, such as those concerned with road planning and building, the further training of enforcement officers and the expansion of facilities for training the driver training instructors. Such support of related automotive safety programs simply represents recognition of the fact that these programs must all be carried on simultaneously if we are to make a maximum effort to reduce the highway traffic toll.

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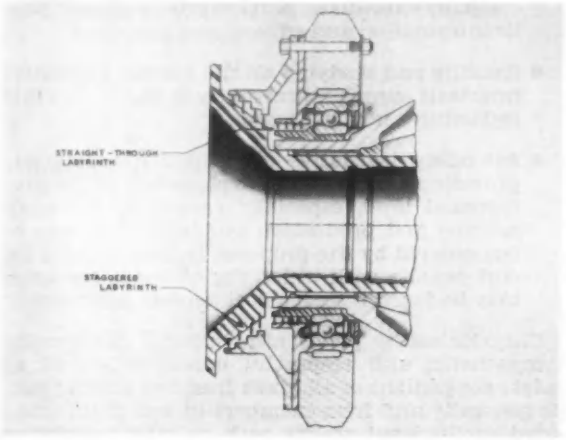

Fig. 1—The classic labyrinth seal consists of a finned bore which rides a close clearance shaft. It is the least efficient of all the positive clearance seals and is now useful as a throttling device only where no other seals can be made to operate.

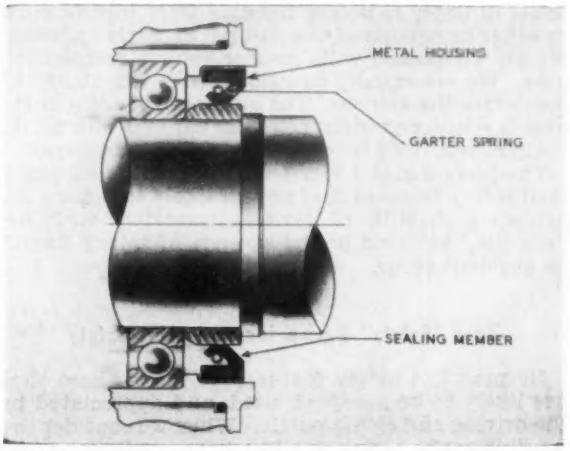

Fig. 2—The lip seal is one of the simplest forms of shaft seal. A resilient material such as leather, rubber, or teflon is held in contact with the shaft by a garter spring. These seals can be used with pressures up to 5 psi at low surface speeds.

Seals for Aircraft

There are many types. Choosing the right one for the job requires careful consideration of the operating conditions to which the seal will be subjected. And it will be up to materials research to supply the even more critical seals needed for tomorrow's turbines.

Sealing Problems

Sealing problems can be grouped into three categories:

1. Problems associated with mainshaft bearing lubrication systems.
2. Problems of containing or controlling airflow within proper channels and preventing excessive loss of this working fluid.
3. Problems dealing with sealing accessory drives.

Mainshaft Sealing Problems

Most powerplants use liquid cooled and lubricated bearings for mainshaft supports. Seals are used to prevent loss of the lubricating fluid. A positive air pressure gradient assists in sealing oil in most mainshaft applications. This is achieved by pressurizing a cavity between two seals.

Since this air pressure is responsive to variations in engine operating conditions, the seals may have to seal air at rather high pressures. To an engine with an airflow of 200 lb per sec, losing ½% air through the seals is relatively insignificant. But, that much air issuing into the bearing cavities of the engine can cause aeration of the sump pumps or excessive coking due to oxidation of the oil. A secondary effect of oil coking may prevent proper performance of the bearing seals. So a main shaft oil seal may have a limit on the amount of air leakage permissible as well as a requirement of minimum oil leakage.

The primary requirement for zero oil leakage, which is difficult to obtain in practice under all operating conditions, is necessary chiefly because of the common practice of using compressor bleed air to pressurize or refrigerate aircraft cabins. Any oil leakage into the compressor airflow can cause serious cockpit contamination problems due to the formation of toxic fumes.

Oil leakage beyond the compressor section is also important because of the limited capacity of the oil tank. Also, due to coking, the oil flow passages in the engine may be restricted. The smoking characteristics of the engines due to oil combustion may also influence the ultimate combat characteristics of the airplane by producing (or not producing) a tell-tale smoke trail.

A positive air pressure gradient does not guarantee zero oil leakage. At times one can observe low pressure oil leaking into a highly air pressurized zone. This phenomenon is an excellent example of how important hydrodynamic forces can be at rubbing mating faces.

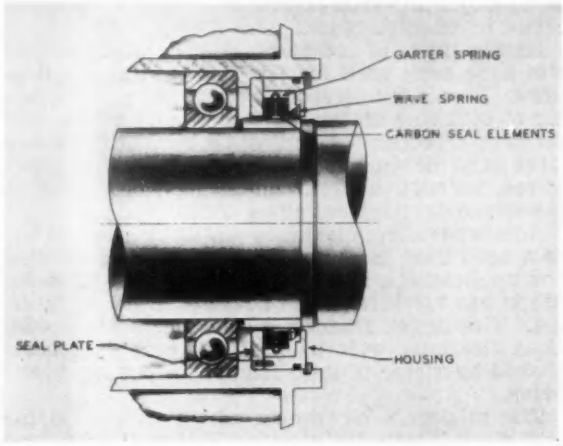

Fig. 3—By using carbon as a rubbing material, rubbing velocities of 300 fps and air pressure greater than 75 psi are possible with this type of shaft riding seal. However, the carbon limits temperatures to about 700 F.

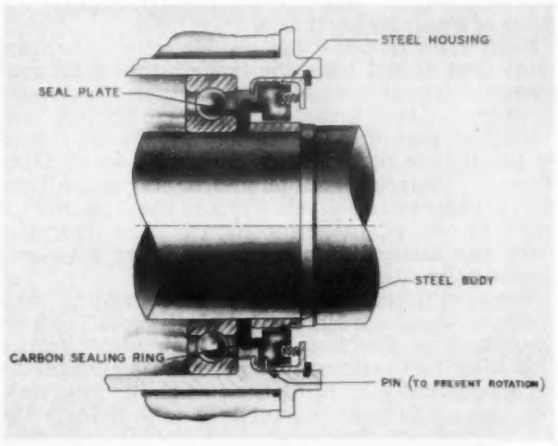

Fig. 4—The face seal usually consists of two optically flat sealing faces contacting at right angles to the axis of rotation. One member rotates with the shaft and the other remains stationary with the housing. The stationary member is usually flexibly mounted to permit relative axial motion between the shaft and the housing. The spring arrangement insures initial contact between the mating faces.

Gas Turbines

Air Sealing Problems

Nearly all the dry running air seals in powerplants are of the positive clearance or labyrinth type. These leak much more than the positive contact types. How to handle this leakage, which in the case of the rear compressor air seal can represent significant loss, presents many problems.

Air seals at the entry and exit of each compressor insure maximum pressure rise with minimum loss. These seals are usually simple devices that consist of a single stationary fin projecting inward from the stator shroud to form a minimum clearance with the compressor wheel. The compressor rear air seal must handle the full output of hot compressed gas at a large diameter. This is one of the more severe sealing problems in the engine. Excessive leakage at this point can significantly reduce powerplant efficiency.

Usually, most of the compressor rotor thrust is taken up by a balancing system using air seals. This arrangement offsets most of the axial thrust of the rotor reducing thrust bearing loads.

Positive clearance air seals have found wide application in conjunction with mainshaft oil seals in forming a pressurized cavity that yields a positive air pressure gradient across the oil seal.

Accessory Drive Sealing Problems

Accessory drive seals involve operation with hydraulic fluids, jet fuels, and engine lubricating oils. Generally, rubbing speeds are small and do not represent a serious problem. But temperatures and

This article is based on four papers in a symposium on High Temperature Dynamic Seals at SAE Annual Meeting, Detroit, Jan. 12, 1956.

"Current Status of Axial-Face Seals"
J. B. Stevens,
Sealol Corp.

"Dynamic Seals for Aircraft Gas Turbine Engines"
Joseph Palsulich and
R. H. Riedel,
The Cleveland Graphite Bronze Co.

"High-Speed, High-Temperature Shaft Seals"
J. W. Pennington,
T. C. Kuchler, and
E. J. Taschenberg,
Koppers Co., Inc.

"Wear of Materials for High Temperature Dynamic Seals"
R. L. Johnson,
M. A. Swikert, and
J. M. Bailey,
Lewis Flight Propulsion Laboratory, NACA

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pressures are constantly increasing beyond the range of available materials.

Many seals in use today use elastomeric components that do not have the temperature resistance necessary for engines of the near future. All-metallic seals are being considered for these applications.

High temperatures in accessory devices are caused by the higher flight speeds demanded of military aircraft. High skin friction and/or stagnation have raised temperature levels beyond the capacity of many of the engine components. New hydraulic fluids and lubricating oils are now being developed for operation above 450 F.

Pumps will probably have to accommodate fuels at 500 F. This high temperature is the result of heat absorption in the wing tanks from skin friction. This high fuel temperature problem is continually being aggravated by using the fuel as the heat sink. The seal manufacturer is obliged to anticipate the requirements of the future and provide seals that will operate under these severe conditions.

Types of Seal Designs

The types of seals that have found application in the solution of these problems can be generally classified as:

1. Positive clearance or labyrinth seals
2. Shaft seals
3. Bore seals
4. Face seals

Each of these types has distinct advantages and disadavantages which govern selection of design for a specific sealing problem. Consideration must be given to the following major factors to arrive at the best solution to the problem.

- Temperature of operation
- Pressures to be sealed
- Rubbing velocities
- Allowable leakage rate
- End movement to be accommodated
- Assembly procedures and limitations
- Cost

Positive Clearance Seals

The labyrinth seal, Fig. 1, consists of a finned bore within which rides a close clearance shaft. It is the least efficient of all the positive clearance seals. But, because it is easy to apply, it has been used for most mainshaft engine seals. Because of their superior efficiency, positive clearance seals have replaced the labyrinth in most current powerplants. In fact, the labyrinth seal is now useful as a throttling device only where no other seals can be made to operate.

Better sealing efficiency is obtained with the shaft mounted step labyrinth or the self-grooving labyrinth. These designs add a flow reversal to the velocity head dissipation at each throttling. While the classic labyrinth design requires large clearances to compensate for shaft run-out and thermal or creep expansions, the self-grooving type permits minimum clearances by using shaft mounted knife edges which cut into a soft liner to absorb run-out and expansions. This is probably the most efficient of all labyrinth versions, and has found wide application in small turbines.

Mating liners of cadmium, lead, or tin-base babbits have been used for low temperature applications. Higher temperatures require the use of brazing or soldering materials, aluminum, bronzes, and carbons. Problems of mating fin compatibility and large axial movements have not yet been completely solved, but enough improvements have been made to encourage development along these lines.

Another positive clearance seal, which has in the past been used in many steam turbine or packing box applications, and now is being considered for use in gas turbines, is the floating throttling bushing. This design features a solid sleeve fitted with close clearance over a shaft. Sealing is accomplished by virtue of fluid friction in the small annulus.

The minimum clearances which can be maintained are largely functions of heat dissipation and lubrication of the particular application. With careful attention, a throttling bushing can operate successfully with clearances as low as 0.0003 in. This results in much less leakage than a simple labyrinth seal.

Since hydrodynamic lift tends to prevent running contact between the shaft and bushing, wear is not a serious problem except during starting or stopping the shaft and in gas seals where the speed is too low to produce sufficient lift. Tests reveal that carbon is an excellent bushing material, since due to its nongalling characteristics, it resists wear during the periods when hydrodynamic lift is small.

The use of an all-carbon close clearance bushing is not practical, however, because the low coefficient of thermal expansion of carbon compared to that of the steel shaft would cause the two parts to contact as the temperature increases. This problem is avoided by shrinking the carbon into a steel band of the same material as the shaft.

As the ambient temperature increases, the steel band expands at the same rate as the shaft, which relieves the pre-stressed carbon, allowing it to expand at approximately the same rate as the steel. In this way, the clearance is maintained at the designed value throughout the operating temperature range.

The carbon bushing is limited to temperatures of about 700 F since the carbon binder breaks down. However, with careful selection of new materials and dimensions, this limit may be raised appreciably. Another important characteristic of this type of seal is the relatively low power consumption required for floating bushing gas seals; however, with liquids the viscosity is high so that the power consumption may be large.

There is almost no set of operating conditions that some type of positive clearance seal cannot accommodate. Practically no limits exist with regard to peripheral speed since no continuous rubbing need occur; in fact, higher velocities improve air sealing efficiency. Temperature requirements can be met by a large number of materials, since materials combinations are not important except for the self-grooving labyrinth or throttling bushing. Thus, this seal is often used where leakage is of no immediate importance. The inevitable urge of progress insists, however, that this type of seal be replaced by the more efficient mechanical seal.

Shaft Seals

A shaft seal is one in which rubbing contact takes place between the seal inside diameter and the shaft. The lip seal, shown in Fig. 2, is one of the simplest shaft seals. Here, a resilient material such as leather, rubber, or teflon is held in contact with the shaft by a garter or finger spring.

These seals cannot operate under high pressure, but can be used with pressures up to 5 psi at low surface speeds. The maximum rubbing velocity which can be tolerated is about 60 fps. Maximum temperature is limited to about 350 F.

A shaft riding seal, using carbon as a rubbing material, has found wide application on main shafts. See Fig. 3. With carbon, rubbing velocities upwards of 300 fps and air pressures above 75 psi are possible. The carbon limits temperatures to about 700 F. Several designs are available, but they all consist of split or segmented carbon rings in an appropriate housing so that gaps are overlapped and urged toward the shaft by springs.

This type of seal performs best when pressurized with air, and is normally so used. By precise manufacturing techniques and careful attention to circularity, squareness, and run-out of the mating pieces, this seal can be made to operate with acceptable air leakages.

For use with high pressure, grooving or undercutting is necessary to effect some measure of pressure balance and so reduce unit loads on the carbon. Internal design is critical. With segmented rings, careful attention must be paid to methods of mounting the sealing segments to minimize vibration of the individual pieces and to insure that the forces at the restraining pins do not interfere with intimate contact of the individual segments with the mating journal.

An alternate scheme uses split rings which are kept in uniform contact with mating members on both the face and inside diameter surfaces by the pressure forces to which the seal is subjected. This type of seal simplifies assembly of engine components and accommodates end movements limited only by the length of the mating journal.

A third variation of shaft seal has had some application in the past for accessories and more recently on the mainshaft. This seal uses a split piston ring held firmly by a contractor spring against a rotating shaft, with which it rotates. Relative motion occurs between the side faces of the ring and the seal housing. Sometimes, a floating ring of special bearing composition is placed between the aforementioned ring and its housing to reduce rubbing velocity and wear.

This seal has limitations with regard to shaft speeds since centrifugal forces overcome the contractor spring force at a definite speed and is not a positive static seal. When designed for high speed service, this seal is difficult to assemble due to the high contractor spring forces which must be overcome when sliding the seal into position on its journal. However, it has the advantages of all metal construction, simplified assembly, and unlimited accommodation of end movement.

Bore Seals

The simplest bore seal consists of a single split ring riding in a groove on a rotating shaft within a matching bore in the housing. Applications have been found for similar schemes using two or three rings in a single shaft groove, two rings in separate grooves, or split rings flanked on either side by solid washers.

Carbon rings are usually used in conjunction with nitrided or chrome plated mating surfaces for high speed and high temperature applications because the good frictional characteristics of carbon are needed.

Some mainshaft oil seal applications, where low pressures are involved, use silver plated steel rings running against nitrided surfaces. This design is not normally satisfactory when used with a positive air pressure gradient of low magnitude.

For higher air pressures, the area of the ring, which is under pressure, is reduced by appropriate grooving to improve balance and minimize the friction and wear. This type of seal operates with ambient air temperatures up to 700 F, air pressures as high as 75 psi, and rubbing velocities up to 200 fps with air leakages below 5 lb per hour. To accomplish this, oil cooling is necessary.

This type of seal has end movement accommodation limited only by the length of the bore within which it operates. Assembly procedures are not difficult, but some difficulty is encountered with breakage of the brittle carbon parts.

Face Seals

The face seal, Fig. 4, usually consists of two optically flat sealing faces contacting at right angles to the axis of rotation. One member rotates with the shaft and the other remains stationary with the housing. One of the members (usually the stationary one) must be flexibly mounted to permit relative axial motion between the shaft and the housing. And some kind of spring arrangement is usually used to insure initial contact between the mating faces. But the greatest portion of the mating face load is derived from the pressure of the sealed fluid.

Where high pressures and rubbing speeds are involved, the mating face forces are adjusted to a minimum consistent with good sealing efficiency and wear life. This is called "balance." Perfect "balance" is a condition where the seal design is such that the fluid forces acting on the seal result in zero load at the mating face. The pressure gradient across the sealing face is assumed nonexistent. By varying the sealing area, which is outside the diameter of the balance line (always located at the secondary or internal seal), any proportion of the sealed pressure can be brought to act at the mating face.

The assumption that no hydraulic forces act on the mating face is, however, a definite over-simplification. Experimental evidence indicates that, under some conditions, these hydrodynamic forces can be quite significant. High mating face fluid pressures can cause distortion, with resultant leakage. Normal practice is to use a balance factor of 2/3, that is 2/3 of the fluid load is balanced. Generally, the seal is designed so that the sealed fluid is on the outside diameter of the mating face, to take advantage of centrifugal force.

A subordinate requirement for the pressure and the spring forces on the flexible sealing member is

to overcome the friction forces within the internal sealing device. These forces do not normally cause difficulties except with piston rings.

Under high fluid pressures, high forces can exist between the piston rings and their mating walls unless the rings are relieved to reduce their area of contact—and this is often done.

Fretting of the rings within the bore is often encountered and can cause sticking on a self-generated basis. Some type of solid lubricant coating can minimize this condition.

At temperatures below 400 F, the use of elastomeric internal seals permits construction of an almost leak-proof seal of high reliability. Fluid pressure greater than 1000 psi and rubbing velocities higher than 200 fps can be handled. But, usefulness as mainshaft seals is limited since it is normally not reliable as an inside fluid seal. The construction of the seal is such that it does not have the necessary accommodation for tolerance build-up and end movement between the shaft and housing which, in modern gas turbines, can exceed 0.50 in. But it is widely used on mainshafts adjacent to ball thrust bearings where the end movement to be accommodated is small.

The use of elastomeric internal seals permits the construction of an assembly that has a leakage rate consistently below ½ cc per hour even under positive oil pressures up to 5 psi. This is advantageous at the colder front bearing locations where oil leakage would result in compressor contamination. Where temperatures are higher however, the use of a metallic internal seal is mandatory and this requires air pressurization of the seal to minimize oil leakage.

Materials Development and Seal Testing

Materials which find preference in present practice are, in order of performance: chromium plated steel, nitrided steel, carburized steel, and cast iron —all run against some type of carbon material. Limited use has been made of bronzes or silver and silver plated steels in place of carbon.

Carbon materials are numerous and can only be identified by a proprietary grade designation assigned by the manufacturer. The compositions are well-kept secrets, but basically consist of various percentages of synthetic or natural graphite, pitch coke, lampblack or calcined coal, compacted with a coal tar pitch binder.

Particle sizes, compositions, and processing procedures strongly influence the performance characteristics of the material. The carbon raw material may be subsequently processed by infiltrating with resins to fill the pores or with metals to augment surface action and increase strength.

Some high pressure liquid seals require a zero-porosity carbon which is usually achieved by multiple resin impregnation. Other seals use a more porous carbon material which can absorb lubricating oil to feed the rubbing surfaces.

The approximate limitations for these conventional running combinations are a temperature of 700 F, and a rubbing velocity of 350 fps, with proper lubrication. These limitations, plus the undesirable fragility and brittleness of carbon materials, make it mandatory to find alternate combinations of materials for future use.

Developing an oil seal satisfactory for operation at temperatures up to 1300 F resolves itself into discovering a combination of materials which are compatible while operating in a variety of media. In this regard the following factors are considered most important:

1. Temperature
2. Rubbing velocity
3. Face pressure
4. Corrosion resistance
5. Friction
6. Availability (low strategic alloy)
7. Strength (fragility)
8. Porosity
9. Lubrication
10. Cooling
11. Media to be sealed
12. Cost

In an attempt to solve this complex problem, The Cleveland Graphite Bronze Co. has been engaged for a number of years in an evaluation program of a wide variety of materials.

The overall objective is to obtain data and justification for trial in oil seal assemblies installed in gas turbine engines. Full-scale tests are extremely expensive in engines and it would be prohibitive to attempt a materials evaluation program by substituting innumerable combinations in a given powerplant installation. Therefore, the need for a test rig to run materials of a uniform size and simple in form, was immediately recognized and resulted in the design and fabrication of such a rig.

This rig is capable of obtaining rubbing velocities up to 300 fps with provisions for running the test specimens up to approximately 800 F. Testing yields data pertaining to behavior of standard materials used in the field and allows a comparison of new material combinations tested.

The second phase of this test program involves the use of a mainshaft gas turbine seal test rig. Oil seal assemblies are evaluated duplicating, as closely as possible, the full range of speeds, lubrication, air and oil pressures, and temperatures contemplated for the engine operation. Promising materials, as determined by the materials evaluation test rig, are tested under these controlled operating conditions to establish the endurance and sealing characteristics when incorporated in a wide variety of oil seal configurations.

This test rig operates at speeds up to 20,000 rpm, rubbing velocities up to 1000 fps, air temperatures as high as 1250 F, and air pressures up to 300 psi. Oil pressures, temperatures, and methods of introduction can be varied widely. Oil seals can also be tested with zero lubrication by using an intermediate seal between the test rig bearing support housing and the oil seal assembly being evaluated. This rig is used exclusively for testing gas turbine oil seals for shafts of 3.5 in. diameter or larger.

We have discussed some of the complexities involved in the development of seals capable of fulfilling the requirements of present and contemplated gas turbine engines. No material combination is evident at present which will be completely satisfactory for the extremely high operating temperatures. Exhaustive materials research and test rig and engine evaluations of many new design concepts will be required before success is definitely assured. However, it is certain that, with diligent application this problem like so many others of the past will be solved, to be supplanted without a doubt by another even more complex.

The gas turbine era will NOT do away with piston rings. Transmissions, hydraulic controls, and auxiliary power units will provide . . .

New Uses for Piston Rings

F. A. Robbins, Koppers Co., Inc.

Based on paper "Recent Developments in Piston Ring Design and Application" presented at SAE Baltimore Section, Dec. 8, 1955.

CONTRARY to what some people think, the advent of non-reciprocating engines for automobiles will not mean the end of piston rings. Besides stationary industrial engines and auxiliary power units which will continue to use reciprocating pistons and piston rings, there will be more use of piston rings in transmissions, hydraulic controls, compressors, and as shaft seals and static seals.

Same Design Principles

The same design fundamentals that apply with reciprocating motion also apply to the design of piston rings for rotary motion or static applications. However, there are additional hydraulic and friction problems. Special materials must be used to minimize wear and scuffing. Manufacturing accuracy and design tolerances are more stringent. In general, however, the following design requirements hold true whether a ring is used with reciprocating or rotating motion, or as a static seal:

1. **Rings should contact the cylinder** over the entire periphery with "light tightness." In addition, unit pressure over the periphery should be controlled to the desired pattern. Four-cycle compression rings and all oil rings should have high tip pressure. Two-cycle compression rings should have low tip pressure to prevent port clipping.

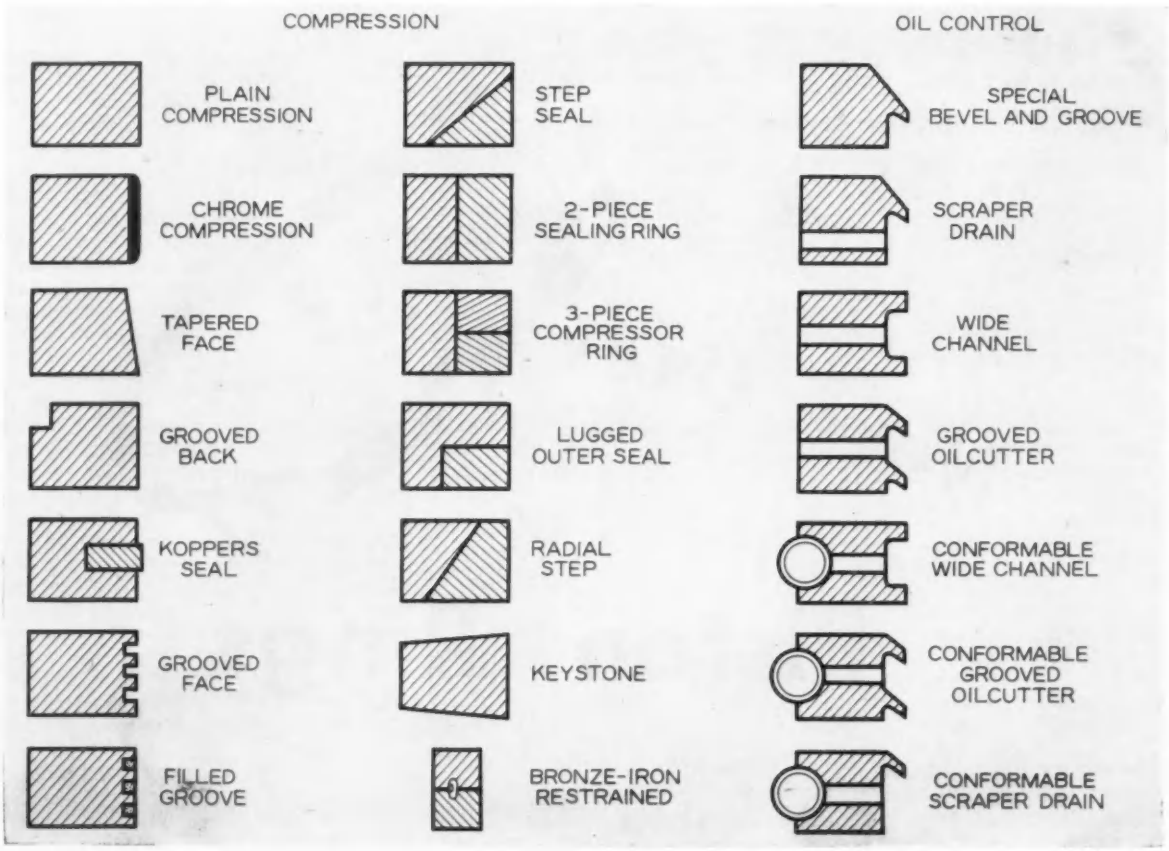
2. **Rings should have proper tension.** The ring wall and tension must be properly balanced so that the ring can be installed on the piston and in the cylinder without distortion when it is opened and closed. Distortion would destroy its contacting pattern with the cylinder.

3. **Rings should be flat.** This is necessary to prevent leakage between the ring and the groove.

4. **Rings should be square.** The cylinder contacting face should contact the ring across its entire width (unless the ring is manufactured out of square for some specific reason).

5. **Ring end clearances should allow for even expansion** so ring butting will not occur. However,

Basic Piston Ring Designs



the clearance should be very small so that leakage can be controlled.

Rings For Modern Piston Engines

Piston rings in modern reciprocating engines have two different purposes:

1. To seal cylinder pressure from the crankcase.
2. To control oil flow from the crankcase to the combustion chamber.

The first function should be as absolute as possible. The second should be commensurate with the lubrication requirements of the pistons and rings. Due to the different functions, two different types of rings are necessary: compression and oil rings.

Compression rings are required to operate at high temperatures and stresses; withstand impact, abrasion, and corrosion; and maintain low cylinder and ring wear under conditions of minimum lubrication. Because of these exacting demands and due to differences in engine design and applications, there is no best ring for all engines.

The most commonly used compression ring material is an open grain pearlitic gray iron of uniform graphite distribution. For improved strength, impact, abrasion, and corrosion resistance, low concentrations of alloying elements, such as nickel, copper, molybdenum, vanadium, chromium, or phosphorus may be specified. The metallurgical structure will depend on the method of casting (individual, static pot, or centrifugally pot). The structure will also depend on the cross-section size of the casting; therefore, composition must be varied to suit.

Centrifugally cast malleable iron is used when higher strength and impact resistance than can be obtained with gray iron is required. This material is usually chrome plated due to its limited scuff resistance. Steel may be used for higher strength but is always chrome plated, because it will scuff if run unplated.

Cylinder and ring wear may be improved by application of chromium plate to the OD of the ring. The improvement will vary from 50% to 500% depending on the application.

Either the plain or chrome plated ring may have the face surface interrupted by grooves, or may have a coarse thread finish, to add scuff resistance. They also may have the face tapered. Taper face rings are usually applied to the lower compression ring grooves with the scraping edge down. The edge bearing results in rapid seating, and also contributes

to oil control by virtue of the scraping action on the down stroke. A similar, though less positive effect, is accomplished by removing metal from the upper inside corner of the ring. This causes a twist in the ring when stressed on installation, causing bottom edge bearing.

The scuff and wear resistance of the plain compression ring can be improved by application of a bronze insert in the bearing face. Non-metallic insert filling is also of benefit under certain operating conditions.

Under some operating conditions, particularly with worn cylinders, it is desirable to use seal joint rings to prevent blowby and oil contamination. For nominal wear, a step seal ring can be used. For heavy wear, it is necessary to use a two-piece ring of the lugged outer seal type. Some engine builders are now specifying step seal rings in new engines to maintain blowby control with ring and cylinder wear.

Oil control rings operate under much less severe conditions than compression rings. They are better lubricated and subject to lower stresses and temperatures. They are less critical of material and all compression ring materials, including unplated steel, are successfully used. All are designed to scrape oil from the cylinder wall into the crankcase. The design requirements depend on the amount of oil which must be removed. Experience indicates basic engine design factors controlling ring design include oil thrown on the cylinder wall by rod and crankshaft, amount of cooling oil deposited on the cylinder wall, fit of the piston, sharpness of piston bottom edge, and cylinder bore distortion in operation.

The efficiency with which oil rings perform their function is due to three things: (1) the pressure against the cylinder surface; (2) the shape of the scraping edge; (3) the provision for oil removal or drainage. It is fundamental that sufficient drainage be allowed. Unit pressure and shape may be interrelated in oil ring design, and unit pressure of sufficient magnitude may eliminate need for shearing action or vice-versa. A controlled angle in the top side of the scraping edge may permit the ring to ride over the oil film on the up-stroke.

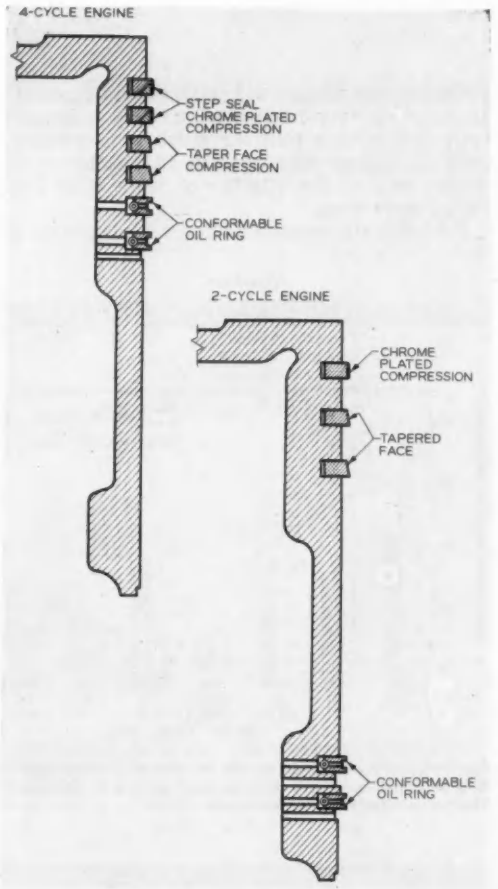
Unit pressure may be increased over that which can be created by tension in the ring by an expander. The most popular ring of this type being used in many current engines and replacement sets is the "conformable" ring. This ring obtains its high unit pressure from a coil spring compressed during installation in a groove in the ring ID. The wall of the conformable ring is kept thin so the action of the expander will keep the ring uniformly contacting the cylinder following the contour of worn or distorted bores. Too, unit pressure and, therefore, oil control is virtually unaffected by wear.

For complete paper on which this abridgment is based, write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

Trends in Piston Ring Arrangement

There are marked trends in piston ring arrangement for modern engines:

- The number of rings is being decreased. No advantage in blowby occurs with more than four compression rings. There is virtually no advantage with more than three. No more than two oil rings are used.
- Ring locations are changing. Top ring is located lower on the piston so that it remains cooler. Oil rings on four-cycle engines are being located above the piston pin to prevent piston skirt scuffing and wear.
- Chromium plated rings increase top ring life and reduce cylinder wear. Several small bore engines have all rings plated sufficiently thick to last the life of the engine.
- Bottom edge bearing rings are being used in the lower compression ring grooves.
- Seal joint rings are being used to improve combustion efficiency and reduce oil and ring belt contamination.
- Oil rings with high unit pressures are using conformable type expanders.
- Pistons are being fitted for minimum skirt clearance. The bottom edge of the piston is kept sharp for scraping. Cam-shaped pistons allow for dynamic loading.
- Ring land radial clearance is being increased to provide sufficient oil drainage.



Increasing Fuel Sensitivity

CARS of the future will have to be designed to burn fuels of ever-higher sensitivity. Reason: Each time fuel octane number must be increased to take care of higher compression ratios, there is an increase in fuel sensitivity—at least with today's refining processes.

Fortunately, engine designers have been aware of this increasing sensitivity and have been combating it by designing engines of greater mildness—with more "mechanical octane numbers" built in them.

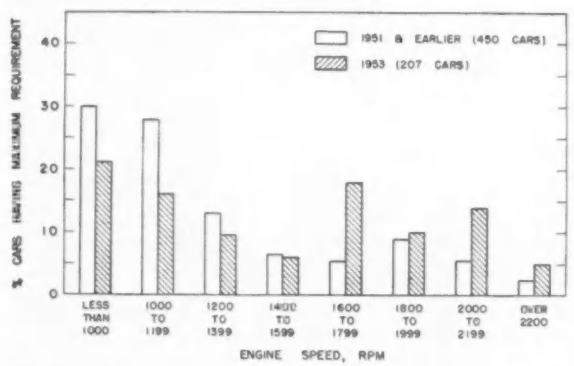


Fig. 1—Speed for maximum octane requirement. Note that for the cars of later model there is a definite shift upward in the speed at which maximum octane requirement occurs.

Modifications already helping modern engines to utilize better the anti-knock quality of these sensitive fuels include:

1. Water jacketing redesigned to minimize engine hot spots.

2. Carburetors redesigned to induce a greater weight of fuel and air per cubic inch of cylinder displacement.

3. Mufflers redesigned to decrease back pressure in the exhaust system, which, in turn, reduces dilution of the fuel-air mixture with exhaust gas in the cylinder.

In addition, these changes have resulted in lower temperatures of gases at the end of the compression stroke.

As a result, today's engines have reached the point where they rate commercial fuels very close to the F-1 (Research) octane number, as compared with cars of 20–25 years ago, which rated fuels at the F-2 (Motor) octane number.

This improved mildness is going to have to keep pace with the increased fuel sensitivity predicted for the future.

In designing these ever-milder engines, automobile engineers will also have to take into consideration two facts:

1. Increased breathing efficiency, which has raised power output for a given engine. This means

Challenges Engine Designers

A. P. Boyd and P. C. White, American Oil Co. (Texas)
and
C. J. Domke, Standard Oil Co. (Indiana)

Based on paper "Future Gasolines for Future Engines" presented at SAE Golden Anniversary Fuels & Lubricants Meeting, Philadelphia, Nov. 10, 1955.

higher combustion-chamber temperatures, which tend to make the engine less mild.

2. Increased use of automatic transmissions of the torque-converter type. These prevent engine loading at low engine speeds, and thus shift the speed of maximum octane-number requirement from low to high speeds.

The shift in engine loading or in maximum octane requirement is illustrated in Fig. 1. In 1951 and earlier model cars, 58% of the cars had maximum octane requirements at less than 1200 rpm. The 1953 CRC octane requirement survey indicated that this percentage had dropped to 37% of the cars having maximum octane requirements at less than 1200 rpm.

The maximum octane requirements and the octane requirements at 2500 rpm for postwar passenger cars are shown in Fig. 2. It will be noted that the gap between the maximum octane requirement and the requirement at 2500 rpm is gradually closing. This decrease in the spread between the maximum and the 2500-rpm requirements is largely due to the adoption of automatic transmissions of the torque-converter type, which raise the speed of maximum octane requirement.

The need for further research on this problem is clearly indicated. Otherwise, gasolines of very high Research octane levels will be handicapped if engines have their limiting octane requirements in the high-speed range, where sensitive fuels are penalized.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

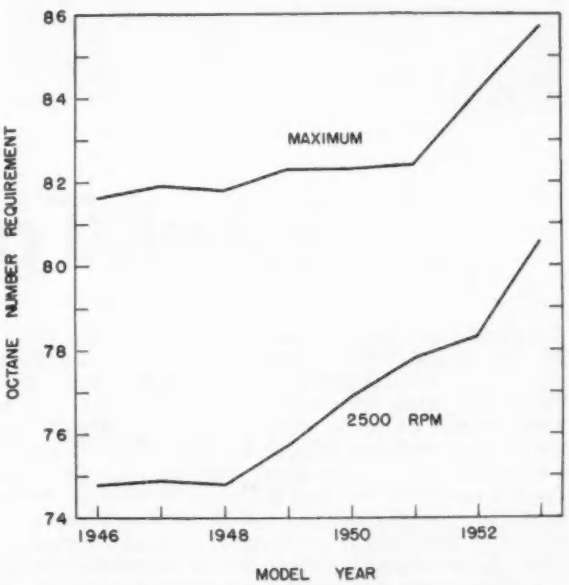


Fig. 2—Maximum octane requirements and octane requirements at 2500 rpm for postwar cars. Note gap between maximum octane requirement and 2500-rpm octane requirement is gradually closing. (Data have been weighted in accordance with national automobile registrations.)

Failures like these . . .

Typical cage cracking and disintegration on two turbojet accessory drive ball bearings

. . . can be prevented, if you know . . .

How To Choose Anti-

AN ideal material for high speed antifriction bearings would have enough alloys in it to produce the required hardness at high operating temperatures, but with no excess alloy or carbon which would make grinding and machining difficult. It would be free from inclusions, have a high tempering temperature, and good dimensional stability. Such a material has not yet been developed; however, these ideal qualities can be used as a guide in choosing available materials for use as bearing in aircraft powerplants. Here are six questions to be answered when considering a specific material:

1. Is it clean?

Non-metallic inclusions in steel used for bearings may be a major cause of fatigue failure. If the steel is melted in a vacuum, the amount of inclusions can be reduced, producing a longer lasting bearing. Too, bearing life can be more accurately predicted, due to greater control of the type and amount of inclusion content.

Generally, inclusions lower bearing life by raising stresses that promote flaking fatigue or spalling in the bearing races and rolling elements. It is believed that most spall failures nucleate about inclusions that are 0.010 to 0.040 in. below the raceway surface and up to 0.070 in. below the surface on heavily loaded bearings. The fatigue cracks progress to the surface of the bearing, after which flaking of the raceway or rolling surface occurs. The non-metallic inclusions located below a depth of 0.015 in., or in an unfavorable position, are difficult to detect with current inspection techniques. It appears that non-deformable alumina and silicate inclusions in steel are the greatest cause of fatigue

John Preston, Jerome Mogul, George Floroff
Wright Aeronautical Division, Curtiss-Wright Corp.

Based on paper "Anti-friction Bearing Materials For Aircraft Powerplants" presented at the SAE Annual Meeting, Detroit, Jan. 10, 1956.

Spalled ball from turbojet thrust bearing

Fatigue spalling of a turbojet main shaft thrust bearing nucleated by a large nonmetallic inclusion

Closeup of spalled roller from turbojet bearing

friction Bearing Materials

failures. The deformable sulfide inclusions do not apparently seriously affect bearing life.

A higher fatigue strength can be obtained in a low alloy steel bearing when the steel is melted in a vacuum than by conventional air melting. It is proposed that vacuum melted bearing steels have an inclusion rating not greater than 1.5 based on the thin series according to ASTM standards. (As vacuum melting techniques are improved it may be possible to lower the inclusion rating to less than 0.5.)

2. Is it hard?

Hot hardness—the ability of a material to maintain its hardness after long use at high operating temperatures—is the criteria which is often used to help choose a material for races and balls or rollers. It is believed that bearing steel should be able to maintain a hardness of 60 R_c. This seems to indicate that up to 350 F, SAE 52100 and MHT must be used. Up to 450 F, HALMO and M-1 must be used.

3. What is its tempering temperature?

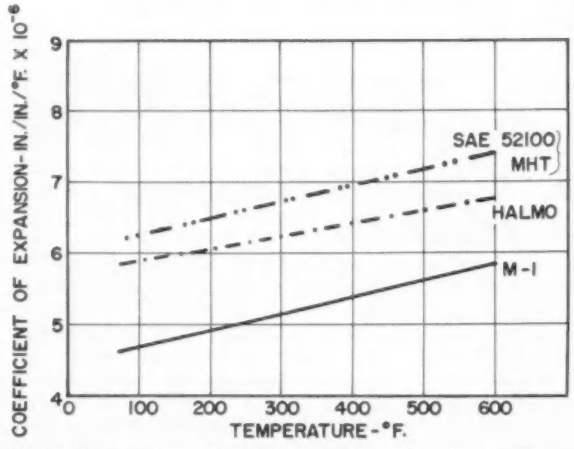
If, during operation, a bearing exceeds its tempering temperature, it will soften, lose its load carrying ability, and soon fail. A chief advantage of bearings produces from HALMO and M-1 is that they are tempered above the operating limit of 450 F. In contrast, the SAE 52100 bearings are tempered at approximately the maximum operating temperature, which makes them susceptible to over-tempering.

A major consideration in the use of vacuum

More Data Needed

INSUFFICIENT data are available on the properties of steels now used for bearings. There is still much to do before antifriction high temperature bearing materials will be considered adequate. Here are suggested areas which need development:

- ★ What effect heat-treatment has on bearing performance.
- ★ More data on vacuum melted steels and further development to get more uniform steels.
- ★ Whether it's better to use forgings or tubes for bearing races.
- ★ Better lubricating oils for aircraft powerplants. The maximum operating temperature of a turbojet bearing is now limited by the oil and not the material.
- ★ Evaluation of the effect of surface finish, misalignment in two-row thrust bearings, and other manufacturing variables on performance.
- ★ Evaluation of new materials for bearing races, rollers or balls, and cages.
- ★ Further investigation on how sub-zero cooling tends to improve bearing life.
- ★ What effect residual elements, such as nickel and molybdenum, in SAE 52100 have on bearing performance.
- ★ Revise method of rating vacuum melted steels for inclusions. Inclusion charts must be brought up to date.
- ★ Find a satisfactory method of testing balls for inclusions.



Effect of temperature on the coefficient of expansion of materials considered for races and balls or rollers of a bearing

melted material has been the response to heat-treatment. So far, none of the vacuum melted bearing steels seems to respond differently to heat-treatment from its equivalent air-melted alloy. This is probably due to the comparatively high carbon content in these steels.

4. Does it have dimensional stability?

The frictional properties of a high temperature bearing are affected by how much its components expand. M-1 has the lowest coefficient of expansion of currently used bearing steels. SAE 52100 has the largest. A low coefficient of expansion is necessary where different materials are used together for tight fits at varying temperatures. High temperature bearings should have the cage, ball, and race made of materials that have similar coefficients of expansion.

The combination of HALMO rollers and cast "S" Monel cage should produce a satisfactory bearing capable of operating at temperatures up to 600 F. Besides a low coefficient of expansion, cast "S" Monel is resistant to galling or seizing where rolling or sliding motion occurs. The combination of cast and wrought material seems to be best for high temperature bearings.

To prevent volume change due to a delayed transformation from austenite to martensite, the amount of retained austenite should be minimized during heat-treatment.

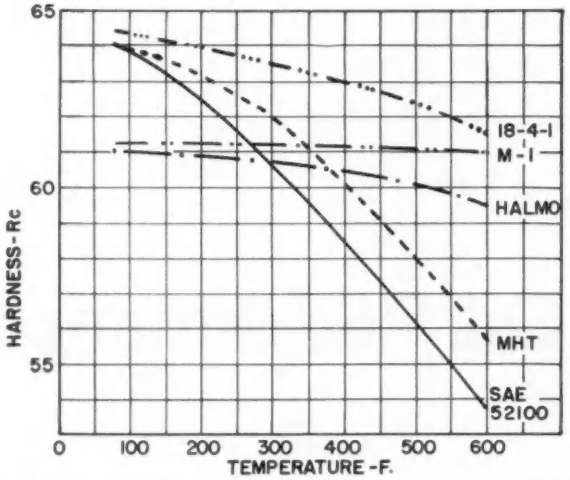
Another consideration is to select a material that has a uniform modulus of elasticity that is not affected by processing variables.

5. Is it easy to work?

Machinability and grindability are other considerations in selecting materials for bearings. The easiest material to process is SAE 52100. HALMO is next more difficult to grind, and this is followed by 18-4-1 and M-1. The two latter materials have similar "hot hardness" but M-1 has a lower alloy content. The excessive alloy content of 18-4-1 outweighs its ease of grinding compared with M-1. Therefore, the two most promising materials for bearings to withstand temperatures up to 600 F are HALMO and M-1.

6. Is it compatible with existing lubricants?

Antifriction bearings are as dependent on the selection of a suitable lubricant as upon materials. Ineffective lubrication may cause the rolling elements in the cage pockets and on the races to seize. The cage material may be smeared on the races and rolling elements. The cage may crack across the ball or roller pockets. Ineffective lubricant may cause race temperatures to rise and cause a phase transformation of the metal on and under the surface of the raceways. The temperature rise may cause thermal discoloration and softening of the hardened parts. The loss of effective lubrication has been attributed to the use of lubricants which deteriorate or have insufficient viscosity and film strength at the operating temperature of the bearing.



Effect of temperature on the hot hardness of typical materials for the races and balls or rollers of bearings

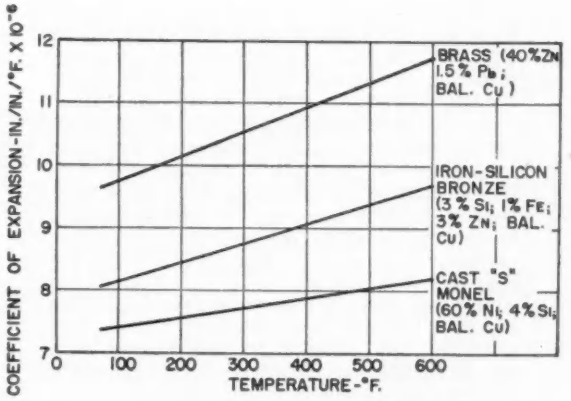
The flash point of the oil determines the maximum safe operating temperature. Synthetic base lubricants must be able to maintain their lubricating qualities from – 65 to 450 F. Besides lubricating, these oils must also act as a heat exchange medium to dissipate the heat generated due to friction.

A few lubricants, such as MIL-L-7808, are capable of meeting these requirements, but they tend to coke at the higher temperature. No other lubricant is commercially available for higher operating temperatures if it must also lubricate at the lower temperature.

For complete paper (in multilith form) on which this abridgment is based write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

MATERIAL	CHEMICAL COMPOSITION - % C	Cr	Al	Mo	V	W
SAE 52100	1.0	1.45	–	–	–	–
MHT	1.0	1.45	1.50	–	–	–
HALMO	0.6	4.25	–	5.25	0.55	–
M-1	0.8	4.00	–	9.00	1.00	1.50
18-4-1	0.7	4.00	–	–	1.20	18.00

Chemical composition of steels for races and balls or rollers of bearings



Effect of temperature on the coefficient of expansion of materials considered for cages of a bearing

Discussion

G. N. Ziegler

International Nickel Co., Inc.

Nickel alloys appear advantageous for bearings at temperatures up to 1000 F because of the effects of a film of nickel oxide.

Too, cast "S" Monel in the annealed and age-hardened condition has the desirable characteristics of retaining its hardness at high temperatures, its low coefficient of expansion, and its resistance to galling in sliding motion. Short-time data indicate almost no change in hardness up to 800 F, and only a small decrease at 1000 F. Since the aging temperature of 1100 F is well above the 450 to 600 F operating temperatures, little, if any, metallurgical change should take place due to thermal effects during operation.

A comparatively new alloy, cast "S" Inconel, also shows promise. It has a low coefficient of expansion and hardness similar to "S" Monel. In Amsler wear tests involving cyclic increases in bearing stresses, average diameter loss of "S" Inconel due to wear was less than 0.001 in. at 65,000 psi under conditions which produced a 0.001 in. diameter loss of "S" Monel after stress had reached only 40,000 psi.

E. E. Hall

Universal-Cyclops Steel Corp.

We too have recognized the inadequacy of the ASTM J-K chart, and are well on our way to producing pictures representing 1¼, 1½, and 1¾ standards for use with vacuum melted steels. We hope to present these soon and, if there is general agreement, we would hope that ASTM adopts them.

J. F. Kahles

Metcut Research Associates

Application of vacuum melted steels will generally provide greater margins of safety. However, more know-how and more data are necessary to take engineering design advantage of the higher fatigue strengths. There is a positive trend toward providing higher fatigue strength in vacuum melted alloys, but statistical analyses also show greater standard deviations. These deviations appear to be caused by a few large inclusions located in highly stressed areas in what generally is very clean steel. Indications are that it will take several years of intensive effort to develop vacuum melted steels to where they will provide properties sufficiently consistent to use their full potential.

Oil Performance

10 oils of 10W-30 grade were tested. All came from solvent-extracted, Mid-Continent base oils of low carbon residue—to which a methacrylate-type V. I. improver was added. . . . Here's what the researchers see in the results.

SPECIFIC differences were found between engines equipped with hydraulic valve lifters and those equipped with mechanical lifters with respect to several performance factors in a series of 50,000-mile low-duty service tests on motor oils.

The existence of these differences was one of eight specific conclusions to be drawn from this attempt to evaluate the performance of a Mid-Continent solvent-extracted base oil when treated with various types and concentrations of motor oil additives. (The test oils are described in Table 1.)

The differences between the hydraulic-valved engines and those with mechanical valves were as follows:

a. In general, the engines equipped with hydraulic valve lifters had considerably less lifter pitting and cam lobe wear than the mechanical.
b. With eight out of ten oils, the heaviest intake valve tulip deposits occurred in the engines equipped with hydraulic lifters.
c. With nine out of ten oils the best gasoline mileage was obtained with the cams equipped with hydraulic lifters.
d. Oil consumption was the lowest with the hydraulic lifter-equipped engine with nine out of ten oils.
e. In eight cases out of ten the highest used oil viscosities, as drained, were found with the oils from the hydraulic valve lifter engines.

Other conclusions to be drawn from the study, include those on sludge prevention, field varnish ratings, oil ring plugging, oil screen plugging, bore and ring wear, and valve train wear shown on following pages.

Test Oils

All 10 test oils were 10W-30 grade, made from the same solvent-extracted, Mid-Continent base oils of low carbon residue, to which a methacrylate-type V.I. improver was added. Viscosities of the finished oils were held between 65 and 66 SUS at 210 F, and viscosity index ranged between 137 and 140. Finished oils were classified as shown in Table 1 for type differentiation and identification.

In order best to describe the oils used in this test, they have been identified under the API Service Classification wherever possible. Some oils did not conform to the popular usage of the API Service Classification, and so liberties have been taken with the system to describe these oils. They are identified as "MS-LD," meaning "Motor-Severe Low Duty." The need for some such service designation may become necessary if severe low-duty oils are gradually accepted.

It might be well to state also that oils blended for this program were "type" oils only and not "production" oils of any kind or designation. However, only commercially used additives were employed.

Table 1—Test Oils Used in 50,000-Mile Severe Low-Duty Field Test

Identification Letter	API Service Classification	Additive Content Identification
A	ML	Base Oil
B_1	MM	Inhibitor F
B_2	MM	Inhibitor G
C_1	MS-DG	Inhibitor F—detergent H
C_2	MS-DG	Inhibitor-detergent J
D_1	"MS-LD"	Inhibitor G—dispersant K
D_2	"MS-LD"	Inhibitor G—dispersant K—detergent L
D_3	"MS-LD"	Inhibitor G—dispersant 2 K
E_1	DS	Inhibitor-detergent M
E_2	DS	Inhibitor-detergent N

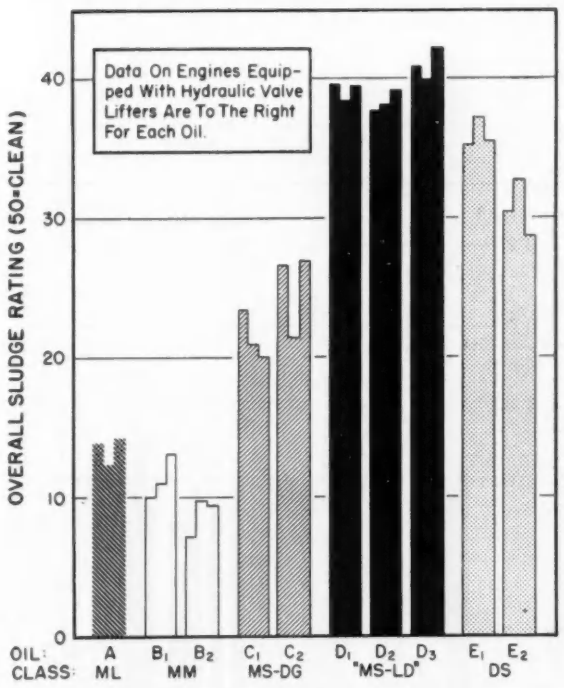
R. H. Albrecht and R. I. Potter, Standard Oil Co. (Ohio)
Kent Hyatt, E. I. du Pont de Nemours & Co., Inc.

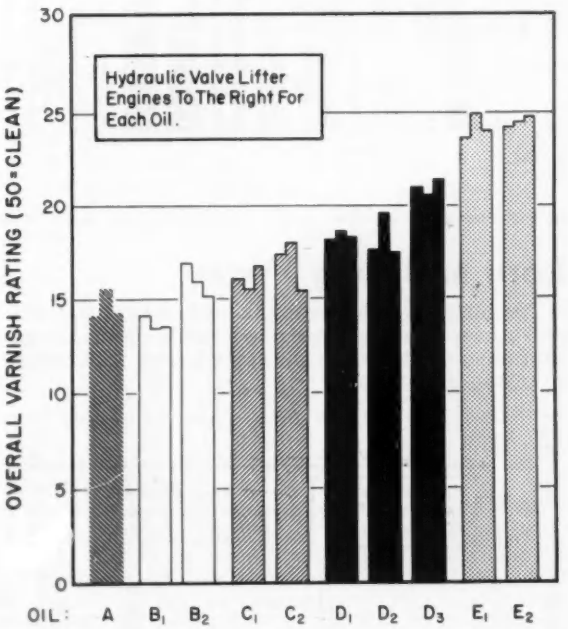
Excerpts from paper "STOP Sludge and CO Clean" presented at the SAE Golden Anniversary Fuels & Lubricants Meeting, Philadelphia, Nov. 9, 1955. This paper appears in full in the 1956 SAE Transactions.

Facts Newly Evaluated

Sludge Prevention

The oils varied widely in their ability to prevent sludging under severe low-duty operation. Service classification ML and MM oils gave extremely dirty engines. MS-DG oils gave only small improvement. DS oils gave moderately clean engines in service. . . . "MS-LD" oils gave superior cleanliness.


Data On Engines Equipped With Hydraulic Valve Lifters Are To The Right For Each Oil.
OVERALL SLUDGE RATING (50=CLEAN)
0
10
20
30
40
OIL: A B1 B2 C1 C2 D1 D2 D3 E1 E2
CLASS: ML MM MS-DG "MS-LD" DS

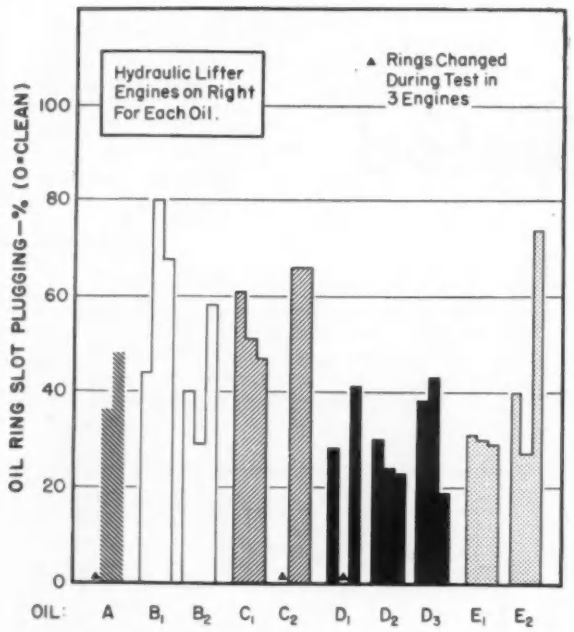


Field Varnish Ratings

Differences in field varnish ratings were small . . . but, generally, higher additive concentrations gave somewhat less deposits.

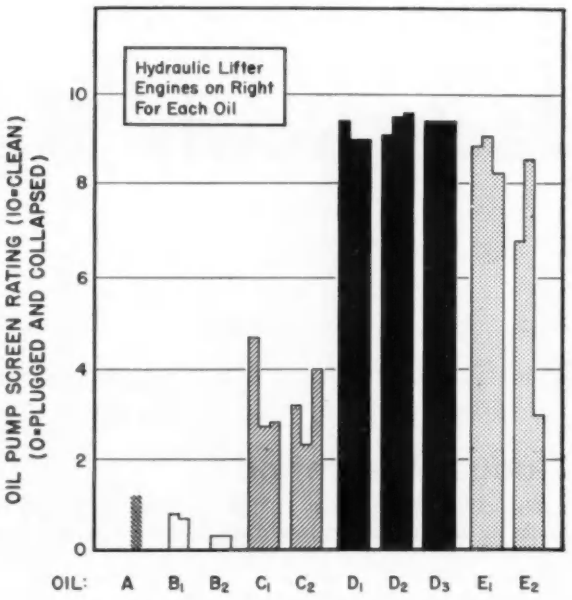
Oil Ring Plugging

Oil ring plugging was generally erratic. The variation between oil types was not as great as might have been expected. The most consistent group performance with the least plugging was found with the "MS-LD" (D_1, D_2, D_3) oils.



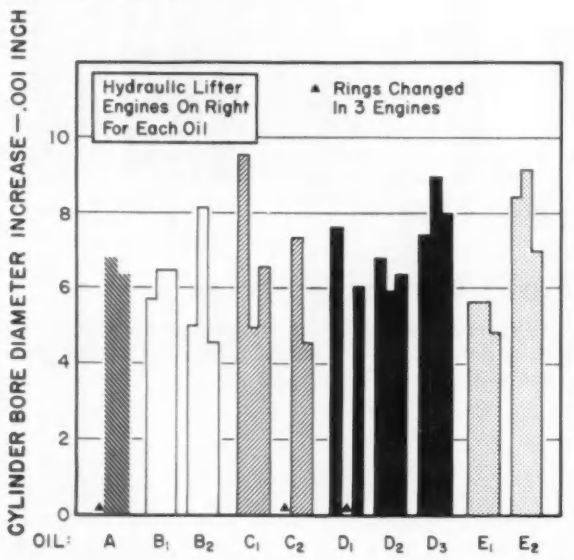
Oil Screen Plugging

Large differences were found in the performance of the several oil types with regard to oil screen plugging. The "MS-LD" (D_1, D_2, D_3) and DS (E_1, E_2) oils were markedly superior in this respect to the ML, MM, and MS-DG oils (A, B_1, C_1, C_2).

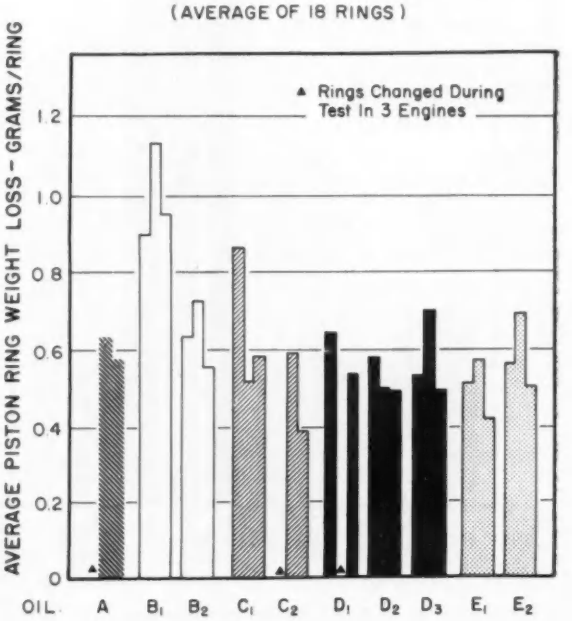


Bore and Ring Wear

The differences between oils with regard to cylinder-bore wear were surprisingly small. With the exception of oil B_1 (MM), the same is true with regard to piston-ring wear.

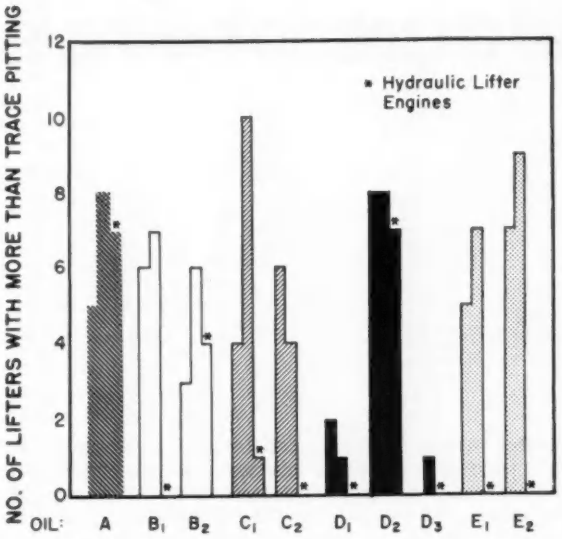


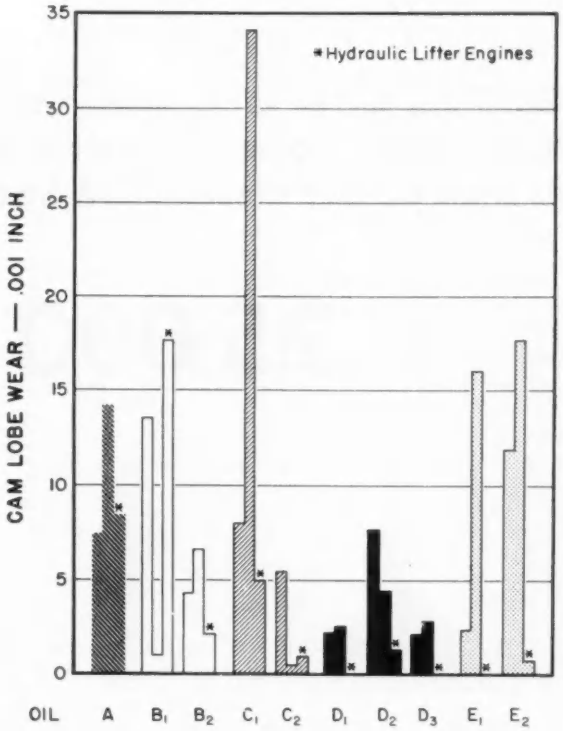
(AVERAGE OF 18 RINGS)

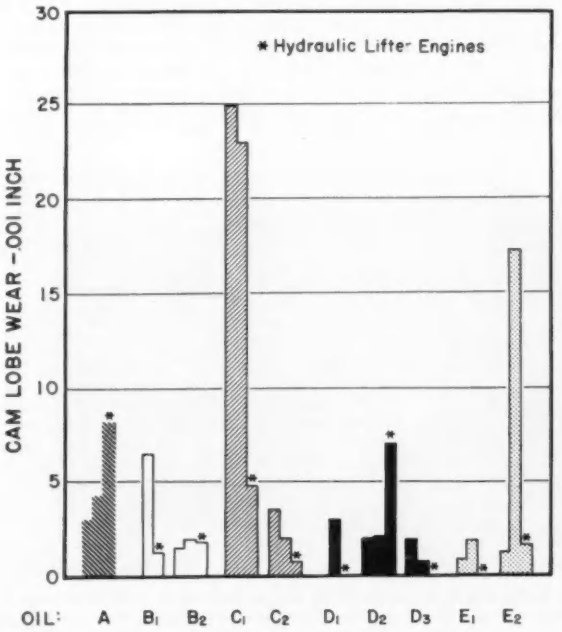


Valve Train Wear

Valve lifter pitting and cam lobe wear were consistently low with "MS-LD" oils, D_1 and D_3 in the engines equipped with mechanical lifters. In those with hydraulic lifters, all the additive combinations except those in oils B_2 (MM), C_1 (MS-DG), and D_2 ("MS-LD") gave good performance with respect to valve lifter pitting and the corresponding cam lobe wear.







These same 10 oils have also been evaluated in duplicate FL-2 and modified EX-3 tests.

Good correlation existed between the FL-2 tests and the field with regard to sludge, total appearance rating, and FL-2 piston varnish versus field sludge.

Good correlation existed in the modified EX-3 test in regard to engine sludging, total appearance rating, and fair correlation on the oil screen plugging.

The modified EX-3 test was more sensitive to oil sludging differences as measured in the field than was the FL-2 test.

It was found both helpful and necessary to modify the API Service Classifications as popularly used in order to differentiate between MS-DG and "MS-LD" oils.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members; 60¢ to nonmembers.

Gasifiers suffer same ailments and respond to same treatments as high output diesels, GM finds in . . .

25,000 Hours of Free

DURING the past few years we have learned most of the facts and foibles of free piston engines. We are convinced of their many real advantages, and we are cognizant of their problems and limitations.

Our knowledge comes from 25,000 hr of free piston engine operation accumulated on:

1. The Muntz P-42 Air Compressor
2. The SIGMA P-13 Air Compressor
3. The SIGMA GS-34 Gasifier
4. The GM-14 Gasifier
5. The GMR 4-4 (Hyprex) Gasifier

When we first became interested in free piston engines we entered into a working agreement with two foreign firms then engaged in the development of this type of engine. There was, at this time, very little commercial application of free piston engines. Although some experimental gasifiers had been installed in minesweepers of the French Navy and free piston air compressors of the types mentioned above were available for sale in Europe, very little was known about their performance, life, or desirability over more conventional diesel engines.

In order to obtain complete information it was necessary to purchase some representative engines and run evaluation tests. This, of course, is what was done—and more recently General Motors has been running two new gasifiers, namely the GM-14 and the GMR 4-4 (Hyprex) engine.

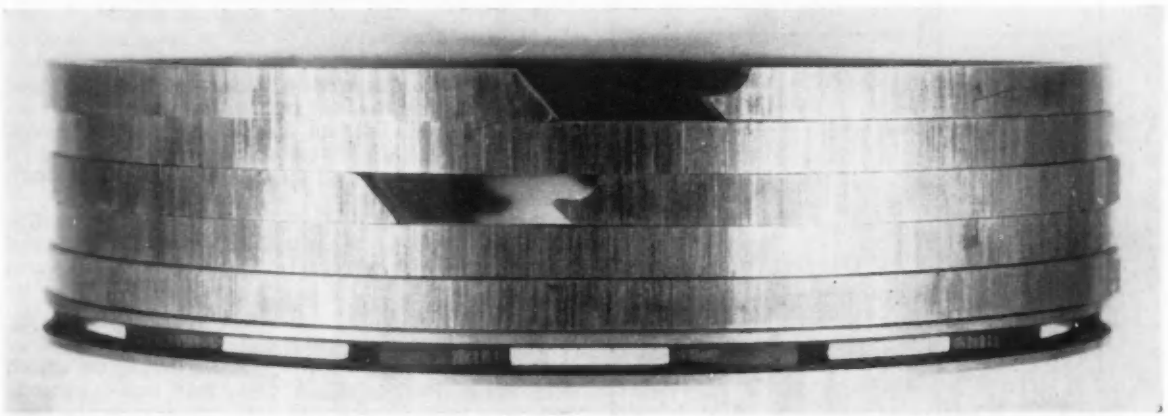


FIG. 1—ORIGINAL RINGS on P-42 free piston air compressor scuffed badly. So lubricant was changed from straight mineral oil specified by manufacturer to heavy-duty lubricant. And other rings were substituted.

Piston Engine Operation

Gregory Flynn, Jr., Research Staff, General Motors Corp.

Based on paper "Observations on 25,000 Hours of Free Piston Engine Operation" presented at SAE National West Coast Meeting, San Francisco, Aug. 8, 1956.

As is the case with any high output engine—and a free piston engine is merely a highly supercharged diesel engine—there are many problems to overcome. Early in our investigations there were several serious problems. During the subsequent development work and the design and development programs of the last two engines, we have been able to eliminate or alleviate all of the major troubles encountered during the preliminary investigation.

Both the P-42 and P-13 air compressors, as originally received, were fairly satisfactory machines. They would start readily and run at various loads for several hundred hours. The main difficulties were piston ring scuffing and breakage, cylinder scoring, and lubricating oil deposits. Fig. 1 shows the piston rings removed from a P-42 compressor after operation at various loads. The lubricant used was straight mineral oil, as specified by the manufacturer. The first tests run, immediately pointed to the use of a modern heavy-duty lubricating oil to reduce deposits and ring scuffing. The rings themselves seemed to need more than just a change in oil to be satisfactory.

Further test work was done using cast iron grooved and ferrox filled piston rings of American manufacture and a popular heavy-duty diesel engine lubricating oil. These two basic changes resulted in a marked improvement in performance, as can be seen in Fig. 2 a photograph of the rings removed after 550 hr of running. Scuffing and scoring were

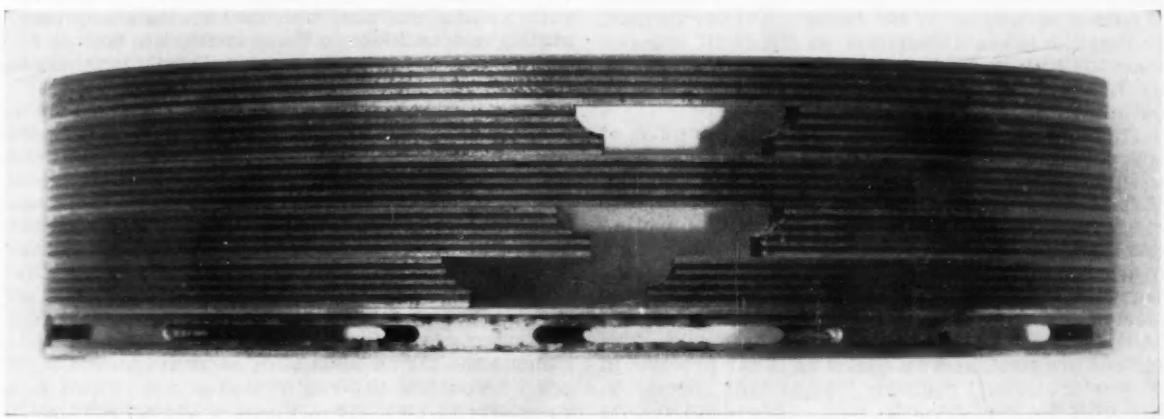


FIG. 2—GROOVED AND FERROX FILLED RINGS made of cast iron according to American practice performed very much better. They eliminated scuffing and scoring altogether and greatly reduced ring and cylinder wear.

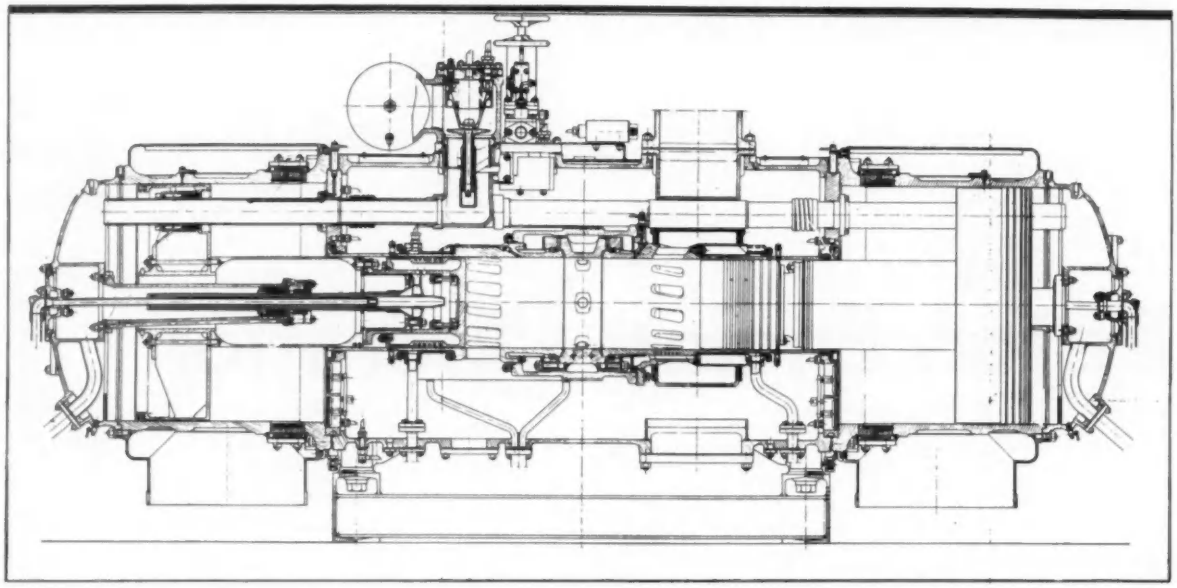


FIG. 3—SIGMA'S GS-34 operates on opposed piston uniflow two-stroke-cycle diesel principle. On outward stroke, air is drawn in through inlet valves into compressor cylinder. On inward stroke, air is compressed through delivery valves into air box around power cylinder. On next outward stroke, this air scavenges exhaust gases from a collector around the exhaust ports. Scavenge air and exhaust are ducted to turbine. Pistons are returned to inner dead point by compressed air in bounce chambers.

completely eliminated, and the ring and cylinder wear was greatly reduced.

Since these and various other modifications, performance tests and several thousand hours of endurance tests have been run with completely satisfactory results. Free piston air compressors are currently very satisfactory commercial machines. However, most of the interest in free piston engines lies in the field of prime movers, which requires the use of a free piston gas generator or "gasifier" and a gas turbine.

Gasifiers

A cross-section of a typical free piston gasifier is shown in Fig. 3. This is the Model GS-34 of the French firm Societé Industrielle Générale de Mecanique Appliquée (SIGMA) as it was three years ago. The engine was rated at 1000 gas hp. (This figure, of course, is reduced by the efficiency of the turbine, so that the brake horsepower on the shaft depends upon the turbine efficiency. For the sake of simplicity, however, we usually refer to free piston gasifier output in terms of "gas" horsepower.)

The engine is a simple machine. It does have, of course, all the attendant oil pumps and injection equipment that any diesel engine requires. Other than that, however, the main moving parts are merely the two piston assemblies and the connection linkage. The pistons operate in a water cooled cast iron cylinder. Each of the cylinders, namely the scavenge and exhaust cylinders, is bolted to a forged steel center section which carries most of the stress at the high pressure part of the firing cycle. The pistons are steel, and oil cooled as is our practice in high output diesel engines. The pistons operate on the cylinder surface with cast copper-lead bronze wear bands, which actually are the bearing surface. The power pistons are directly bolted to the large steel compressor pistons. Here again the piston bearing surfaces are cast bronze wear bands imbedded in the OD of the piston. The compressor cylinders are cast iron.

The engine operates on the well known opposed piston uniflow two-stroke-cycle diesel principle. On the outward stroke of the pistons air is drawn in through the inlet valves into the compressor cylinder. On the inward stroke of the piston air is compressed through the delivery valves into the air box around the power cylinder. On the next outward stroke, this is the air that is used for scavenging the exhaust gases which are collected in a collector around the exhaust ports and conducted through a pipe to the turbine where shaft horsepower is extracted. The pistons are returned to the inner dead point—you will note that we refer to dead points rather than dead centers, since they are constantly variable in a free piston engine—by the compressed air in the dead spaces. These spaces are usually referred to as the "cushion" or "bounce" chambers at the extremities of the machine.

As the pistons move outward they compress air in these dead spaces. This is the air that is used to return the pistons to the inner dead point. All the energy in the firing charge is absorbed by compressing air in the bounce cylinders. The speed of the engine depends upon the masses of the reciprocating pistons, as well as the stiffness of the air springs upon which they act. The two springs are the bounce cylinder pressure and the compression pressure in the power cylinder. Varying either of these three variables will change the speed of the engine.

Since the piston mass is of necessity constant, in order to control the engine and power output it is necessary to vary the stiffness of the air springs in the two spaces referred to. This is the function of the stabilizer or the governor. At times it can take

air from the engine case and feed it into the bounce cylinders, thus stiffening the spring in the bounce space and increasing the stroke and speed of the engine. At other times, if desired, the stabilizer will bleed air from the bounce cylinders into the air box where it is consumed in the combustion process—thus softening the spring or return force on the pistons, shortening the stroke, and slowing down the speed of the engine.

Our initial test work revealed that free piston engines are essentially efficient machines. The thermal efficiency of the GS-34 gasifier, for instance, is 43½%. (Here again reference is made to gas efficiency.) Our test work further revealed that the free piston engine is essentially insensitive to fuel quality. It seems that these engines do not care whether they get fuel with high or low octane or cetane numbers. We have successfully run one free piston engine on a range of fuels varying from 100 octane gasoline, through the gasoline range, kerosene, diesel fuel, bunker C, and crude oil. In addition, we have run it on animal and vegetable oils such as whale oil, cotton seed, and peanut oil. The only noticeable effect on engine output under these test conditions is the power output which varies directly as the content of the fuel being used.

Early test work showed that the fuel consumption of the engine was quite acceptable, the exhaust was absolutely clean, and the engine would run satisfactorily on either diesel fuel, crude oil, or bunker C. There were, however, several inherent mechanical problems existing in the engine itself. These are the problems that are associated with any high output engine development and are probably common to most diesel engines. Namely they were cylinder head or in the case of the free piston engine "center section" stresses, piston ring and cylinder conditions, injection problems, valve problems, lubrication problems, high oil consumption, and air box fires. There were other minor difficulties as well.

The gas turbine, of course, is an essential part of the free piston engine. One of the main advantages of this cycle is that the exhaust gas from the gasifier is only 850 F as it goes into the turbine, which eliminates the necessity for using critical or strategic materials in the turbine blading. It also prevents any damage from vanadium in the fuels, which damage has occurred in high temperature turbines. No trouble of any kind or any servicing has ever been required on the turbines we have tested.

The test installation of the GS-34 gasifier in our Mechanical Test Building is shown in Fig. 4. Since a free piston engine is inherently perfectly balanced the engine was simply mounted on a framework of I beams setting on a wooden floor. It has been running here for three years and so far has not yet moved. The turbine was mounted on a dynamometer bed plate immediately adjacent to the gasifier, as shown. The turbine has an integral reduction gear and is connected to a dynamometer.

The set, as originally delivered, was rated at 600 kw on the turbine shaft. This is equivalent to 803 bhp or approximately 1000 gas hp from the gasifier. Our first tests were, of course, a run-in for the piston rings and check runs to determine that the turbine and gasifier controls were working properly.

Fig. 5 shows the power output of the turbine, plotted against gas pressure.

Fig. 6 is a plot of fuel consumption versus load. As

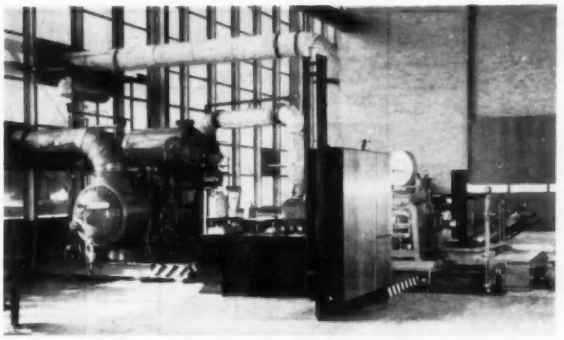


FIG. 4—TEST SET-UP FOR GS-34 GASIFIER does not have to be bolted to floor because gasifier is inherently balanced. Turbine is mounted on dynamometer bed plate adjacent to gasifier.

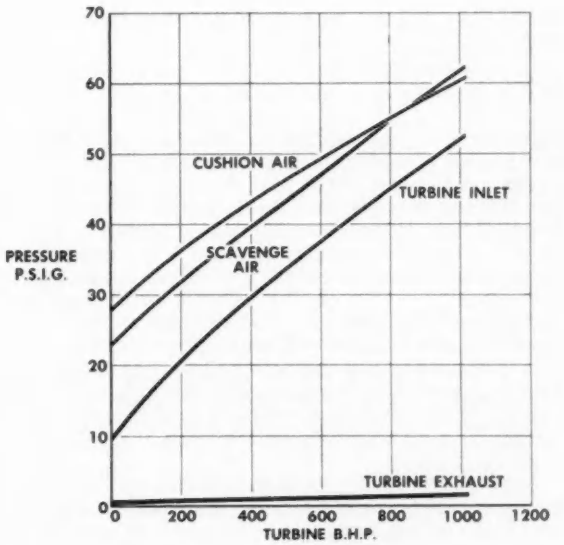


FIG. 5—TURBINE POWER versus gas pressure.

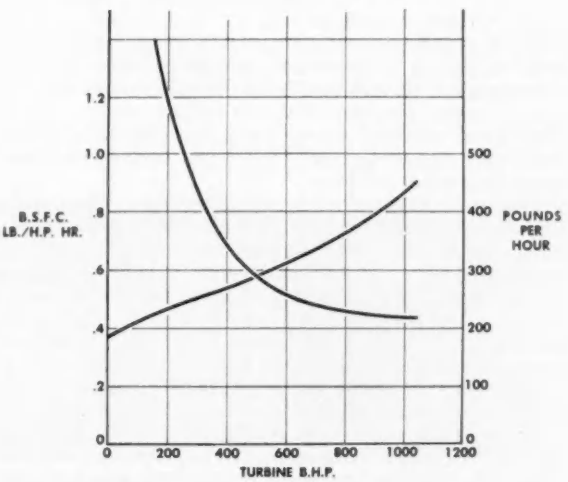


FIG. 6—FUEL CONSUMPTION of free piston engine.

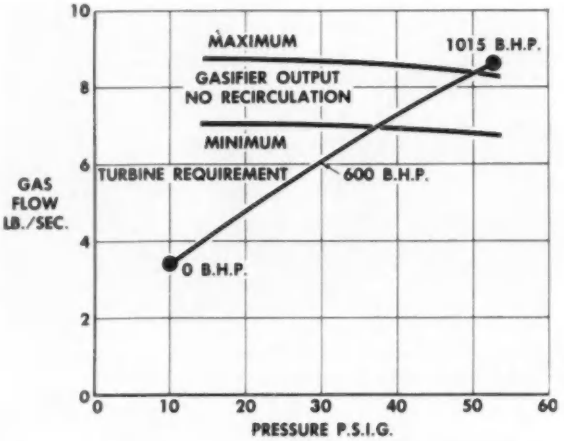


FIG. 7—GAS FLOW WITHOUT RECIRCULATION versus turbine demand.

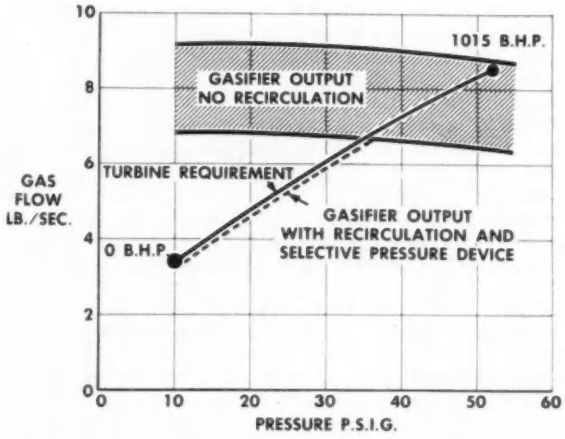


FIG. 8—GAS FLOW WITH RECIRCULATION versus turbine demand.

can be seen, the part load fuel economy of an inward compressing engine is not very attractive at low loads. This is due to the fact that at low horsepower the turbine requires only a small amount of gas and the gasifier's output is restricted as shown in Fig. 7. As fuel to the gasifier is reduced the pistons slow down and reduce their stroke. The minimum stroke is limited by a cam on the injector control so that the piston must always have sufficient stroke to uncover the ports to prevent stalling the engine. Thus, if it is desired to run the turbine at lower output, the excess gas must be thrown away through the bypass valve. This, of course, represents a direct loss of energy and an unfavorable low-load fuel consumption.

Such a powerplant, though satisfactory for powerhouse service, would be quite undesirable for locomotives, for instance, where as much as 50% of the operating time is at low-load or idle throttle position.

Shortly after we began running our test, two modifications showed great promise of alleviating the part-load fuel consumption. These were a selected pressure pickup unit for the stabilizer, and the use of a recirculation valve from the gasifier air box. Addition of these two devices reduced the fuel consumption at idle to a level comparable to that of a good diesel engine. Thus, it was possible to consider such a power source for a locomotive or other vehicular application where a great deal of low load operating must be done.

The recirculation valve is quite simple. It merely bypasses the air from the airbox around the cylinder back to the air inlet. As the air goes around and around the loop it gets heated with each pumping stroke of the compressor pistons until its temperature is raised to a rather high level. This allows the gasifier speed and compression ratio to be reduced and still maintain sufficient heat in the combustion chamber to ignite the fuel when it is injected. Thus, the compression ratio which at full load is approximately 50 to 1 can be reduced to 10 to 1 at idle with the recirculation valve open. With these two devices it is then possible to match the turbine gas demand curve perfectly all the way down to 0 hp or idle on the gasifier. This, of course, would make it quite an attractive powerplant for vehicular service.

As seen in Fig. 8 the addition of a recirculation valve permits the gasifier output to be perfectly matched to the turbine requirement right down to idle. The idle fuel rate was reduced from 180 to 40 lb per hr.

After the aforementioned modifications, the gasifier and turbine performance were eminently satisfactory throughout the load and speed range. Rapid changes in load could be made with no difficulty, and the fuel consumption was considered satisfactory with a turbine of this efficiency. In addition, the engine would run equally well on either light diesel fuel or bunker C.

The first complete overhaul and inspection revealed the major problems in free piston engines were essentially those of any high output diesel although perhaps more pronounced because of the high temperatures and pressures in the combustion chamber. The main problems were:

1. Cylinder wear
2. Diesel piston ring wear, scuffing, and breakage
3. Compressor piston ring wear, scuffing, and breakage
4. Intake valve blade failures
5. Oil leakage past seals resulting in valve deposits and airbox fires
6. Piston ring groove deposits
7. High piston cooling oil consumption

While we tolerated and repaired these difficulties as required, several hundred hours of engine operation were accumulated. Since engine performance in terms of output and fuel consumption was considered satisfactory it then became necessary to establish the life of the engine by running an endurance test at full load on bunker C.

Test work on the smaller free piston air compressors had demonstrated that better piston rings and

modern heavy duty lubricants made a marked improvement in ring life. Therefore, prior to running an endurance test, the lubricating oil was changed to a medium-viscosity-index base oil with a Series 2 additive level plus zinc dithiophosphate. In order to promote ring seating, new French piston rings were given a ½ deg taper and the cylinders were "lubricated."

It was also felt that with these and other improvements the gasifier rating could be increased 25% from 1000 to 1250 gas hp. A test goal was set up to run 1000 hr at full load on bunker "C" fuel with a minimum availability of 85%.

An endurance test was started using light diesel fuel. The engine was run on a 24 hour per day schedule six days per week. Each Monday morning before starting, the conditions of the piston rings were observed through the intake ports. After 600 hr at full load the fuel was changed to bunker "C." This fuel was the same as that being supplied to the boiler house for making steam to heat our buildings. Each truck load of fuel was slightly different. However, a fairly typical analysis is shown in Table 1. The fuel used averaged 3½% sulfur, with some deliveries running as high as 4.2%.

The endurance test was continued at full load for 1100 hr to achieve our original goal of 1000 hr on heavy fuel. At the end of 1728 total hr the test was stopped and the engine dismantled for inspection. The availability of the engine at the end of the test was 91.2% at full load, and 95% overall. That is 95% of the available working hours the engine was running and 91.2% of the available hours the engine was producing 1250 gas hp.

The 5% lost time was caused by casualties that necessitated shutting down the engine for repairs. The main cause of the engine shutdowns was failure of intake valve blades. As shown in Fig. 9, the tips of the blades would fatigue and chip out. When the failures progressed below the sealing surface the result was back flow and loss of power. The other two principal troubles were injector seal leakage and precombustion chamber failures from cracks in the welds.

Inspection of the piston rings, pistons, and cylinders revealed excessive wear and scuffing. The copper-lead of the wear bands had corroded and worn sufficiently to allow the steel piston ring lands to contact the cylinders with consequent scuffing of the piston itself and damage to the cylinder.

Previous experience in Europe had indicated that air box fires would occur at regular intervals. These fires do no damage other than stopping the engine by consuming the oxygen in the airbox. They are caused by lubricating oil deposits in the airbox, which come from leaky seals on the balance tube and connection linkage rods. Only two fires occurred during the entire test, neither of which stopped the engine. This remarkable performance, as compared to previous history, was attributed to the use of a modern heavy-duty lubricant. Oil leakage past the seals was appreciable, but the deposit formation was much less than that observed in European engines.

Results of this first long term test were so encouraging that it was decided that redesigning many basic parts could result in much superior engine performance and a second test goal was set at 5000 hr at a minimum of 85% availability.

Several hundred engineering changes were incorporated and the new engine was designated the GM-14. The most notable of the changes were as follows:

1. **Intake valves** fatigue tested on a bench test rig indicated that considerable improvement in valve life was possible. New valves were made up of aluminum segments instead of steel, and valve blades made of a suitable spring stock correctly processed for their ultimate use.

2. **Cylinders** were given a surface finish specification in accordance with our diesel engine practice and were "lubricated."

3. **Piston rings** processed in accordance with our diesel engine experience were taper faced, grooved and ferrox filled.

4. **Bronze wear bands** on the pistons were discarded because of the high sulfur attack, and a special steel-backed aluminum alloy was substituted. The wear bands were grooved similarly to the piston rings to reduce land width.

5. **Pre-combustion chambers** were redesigned and made from a more suitable material with better cooling provided.

6. **Injector seals** were made from a more suitable material.

7. **Balance tubes, connecting links,** and all sliding seal surfaces were hardened and lapped to a specified surface finish to reduce oil leakage.

8. **Delivery valve plates** were redesigned for water

Table 1—Oil Sample Report for Typical Bunker "C" Fuel Used During Endurance Testing of GS-34

Specific gravity at 60 F	0.994
API gravity at 60 F	10.9
Viscosity at 122 F (SFV)	149
Flash point	240 F
Fire point	275 F
Pour point	35 F
Sulfur	3.31%
Ash	0.02%
Carbon	16.25%
Initial boiling point	345 F

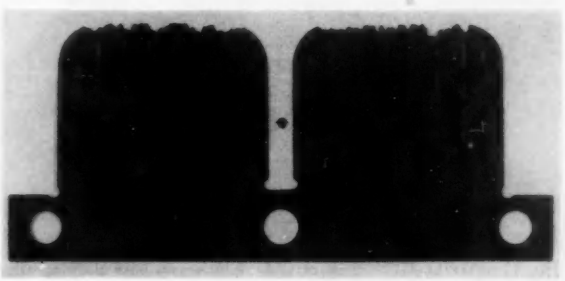


FIG. 9—DAMAGED INTAKE VALVE BLADES caused back flow and loss of power. Tips failed in fatigue and chipped.

FIG. 10—EXHAUST PISTON RINGS from GM-14 gasifier show that redesign from the GS-34 decidedly improved ring life. No. 2 ring is in excellent condition. Top ring is, however, still critical.

FIG. 11—POWER CYLINDER of GM-14 shows no port clogging after 4500 hr of operation. Only deposits are on three intake ports located in a region of restricted airflow in the engine case. No deposits have ever been found on exhaust ports.

cooling to reduce valve deposits and valve leakage.

A second endurance test was started in the fall of 1955 and was run as before at full load on bunker "C" fuel, 24 hr per day, six days per week. Due to interference with the Technical Center dedication ceremonies in May of 1956 the test was terminated at 4500 hr.

The GM-14 gasifier represents a marked improvement in engine durability over earlier free piston engines. The three basic problems encountered in the first 1700 hr test were completely eliminated. No shutdowns were caused by injector seal leakage, precombustion chamber failures, or intake valve failures. Valve blades removed after 4500 hr at full load showed absolutely no evidence of fatigue failure.

The proper hardness and surface finish of the sliding seal surfaces had eliminated seal scoring and had reduced the oil consumption from 0.4 to 0.08 gal. per hr. This greatly reduced the deposits in the airbox and prevented the occurrence of air box fires.

Aluminum wear bands resulted in a marked reduction in wear band wear (or corrosion) from 0.010 to 0.0028 per 1000 hr.

Grooved and ferrox filled piston rings eliminated scuffing and greatly reduced the ring wear.

A close up of the exhaust piston rings is shown in Fig. 10. The most critical part of the engine is still the top ring. However, the latest changes have decidedly improved ring life. The No. 2 ring on both pistons, for instance, is in excellent condition with absolutely no signs of scuffing and has a very acceptable wear rate. It is expected that further changes now being tested will result in much improved top ring performance.

Perhaps it should be pointed out that piston ring service in a free piston engine is not quite as serious a problem as in more conventional diesels. The GM-14 engine can be shut down and pistons removed for a ring change in less than an hour.

Fig. 11 shows the power cylinder after the 4500 hr test. One of the remarkable things about free piston engines is the lack of port clogging problems. As can be seen, there are no clogged ports and the only deposits noted were on three intake ports located in a region of restricted airflow in the engine case. No deposits of any kind have ever been found in the exhaust ports.

Since we began development work on this free piston engine, we have increased the rated power output by 25%. The life of all of the critical parts has been extended until we can run a 4500 hr test with over 90% availability. The engine runs satisfactorily on heavy fuel with absolutely clean exhaust.

We are now confident that the GM-14 engine will be a contender for a place in commercial power generation and that continued development work will result in further increases in power, economy, and reliability.

Acknowledgment should be made of the cooperative efforts of the engineers of the Electro-Motive and Cleveland Diesel Divisions of General Motors as well as Societé Industrielle Générale de Mecanique Appliquée and Societé d'Etudes de Matériel Electrique in France for the rapid advance in free piston engine development over the past three years.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

CRC survey asks 100,000 cars . . .

"Are You Satisfied with the Gasoline You're Using?"

The collective answer appears to be . . .

"Yes."

ACCORDING to a CRC survey, which was taken in 1953 and 1954, most fuels can be handled in most passenger car engines without much vapor lock, hot starting, or hot stalling problems. (See SAE Journal, April, 1956, pp. 66–69.) However, high underhood temperatures—following operation at high speeds—tend to prohibit use of more volatile gasolines. Power accessories and crowded engine compartments aggravate the situation by increasing underhood temperatures, particularly in the summer.

• **What about the future?**—If future engines are designed with higher horsepower, and more power accessories are crowded into the engine compartment cutting down air circulation, the engine will have a tougher job rejecting heat. Then vapor may form in the fuel lines. Conversely, if oil refiners increase the volatility of the gasoline, making it more susceptible to vapor formation, car designers will be hampered in their efforts to build more power, lower hood lines, and more accessories into future cars.

• **Cooperation is answer.**—There is no doubt that this incipient problem will be solved, as it has been in the past, by cooperation between engine designers and gasoline producers. Motor car manufacturers will continue to improve vapor handling characteristics; petroleum suppliers will produce fuels suitable for higher compression engines without increasing the Reid vapor pressure or vapor locking tendencies materially.

• **Survey pinpoints problems.**—A survey conducted by the Volatility Group of the Motor Fuels Division of the Coordinating Fuel and Equipment Research Committee of the Coordinating Research Council, Inc., observed over 100,000 cars in different locations under different conditions. When stalling, difficult starting, or loss of power indicated fuel handling difficulties, the conditions and trouble were noted.

The amount of trouble differed considerably from one location to another. The greatest influence on engine operation is probably the temperature of the

The Authors

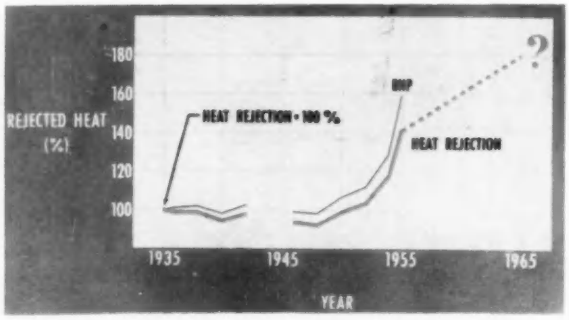
This article is based on the paper **"A Recent Look at Some Problems Related to Gasoline Volatility"**—and **discussion** of it—presented at the SAE Golden Anniversary Fuels and Lubricants Meeting, Philadelphia, Nov. 9, 1955.

The authors are:

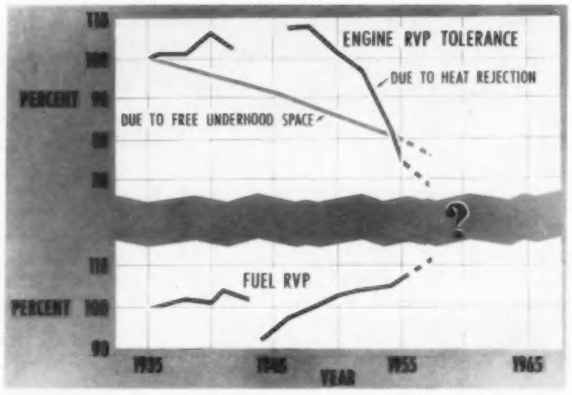
W. P. Dugan, Sun Oil Co.
F. T. Finnigan, Pure Oil Co.
J. G. Moxey, Sun Oil Co.
Gilbert Way, Ethyl Corp.

Discussion by:

J. B. Duckworth, Standard Oil Co. (Ind.)
A. H. Winkler, Eclipse Machine Division, Bendix Aviation Corp.
A. E. Cleveland, Ford Motor Co .



PRESENT engines must handle about 1½ times as much heat as was dissipated in the 1945 automobile. Since the rejected heat is approximately proportional to horsepower, further increases in power will create even greater heat rejection problems.



CROWDED engine compartments and lowered engine Rvp tolerance will, if they continue, present fuel handling difficulties. Engine designers must take advantage of every known principle to avoid vapor lock. Gasoline producers must continue to make high compression fuels without materially increasing Rvp or vapor locking tendencies.

fuel in the different parts of the fuel system. This temperature is determined by the type of operation the car is undergoing, the length of the soak period prior to observation, by wind velocity, cloud cover, and the ambient temperature.

For example, fuel line temperatures increase faster when climbing a mountain grade than when driving along a level road where engine output for the same speed and ambient temperature is lower. Similarly, carburetor bowl temperatures would be higher after a 10 to 20 min soak than after some shorter or longer period.

Altitude is another factor that differs between locations and would be expected to affect fuel vaporization.

Therefore, the survey results must be considered by location. We cannot assume that they hold true throughout the country. Too, the survey applied only to summer operation on gasolines of summer volatility. It does not cover the problems encountered during spring and fall transition periods or the occasional warm day that sometimes happens in the wintertime. An unseasonable, hot day, occurring during a period when fuels of relatively high volatility are being used satisfactorily, may result in considerable fuel handling difficulty.

Survey Statistics

HOT STALLING—any stalling after a normal stop or refusal of the engine to continue running after a restart.

59,872 cars were observed at 11 different locations such as traffic lights and toll gates where vehicles are normally brought to a stop and allowed to idle momentarily. Highest incidence of stall occurred at a parking area where cars were allowed to soak for some time after driving on a 70 mph turnpike.

There was less stalling during city traffic driving than there was at the stops after open road driving.

There seemed to be little direct relationship between ambient temperature and the stalling in the observed cases, indicating that at least part of the trouble was not due to "hot fuel handling" difficulties.

HOT STARTING—a measure of how long it takes to start a vehicle after it has been operated for some time and shut off for a relatively short soak.

Some 3867 cars were observed at nine different locations such as supermarket parking lots, a turnpike restaurant, and a ferry boat waiting line.

Slow starting was most prevalent at the same 70 mph turnpike stop at which the most hot stalling occurred. In general, city driving developed fewer hot starting problems than high speed turnpike driving. The effect of ambient temperature is not definite since hot starting was more difficult at higher ambient temperature in only two of four locations observed.

There were no starts that took longer than 3 sec at cars observed waiting for a ferryboat. It may be that the jockeying and idling that is usually a part of loading a ferry cooled fuel system temperatures to the point where no hot starting difficulty was encountered. Similarly, a low incidence of difficulty at a supermarket parking lot may have been due to relatively low fuel temperatures as a result of the cars' having been driven only a short distance before parking.

VAPOR LOCK AFTER SOAK—stalling after a car has been "soaked," started, and driven about 0.2 mile.

RUNNING VAPOR LOCK — stalling after steady driving.

More than 44,000 cars were observed at 19 different locations at various altitudes.

Below 2000 ft there was no large increase in running vapor lock as temperature increased. (However, no high temperature data were obtained under

the steep highway grade conditions that are most apt to produce this type of difficulty.)

The soak type of vapor lock occurred most at a 70 mph turnpike stop below 2000 ft altitude. There was a marked increase in the incidence rate as the temperature increased. Up to 25% of the total (1519) cars observed at this location encountered some degree of vapor lock. Most involved only slight loss of power, misfiring, backfiring, and rough running rather than complete stalling of the vehicle.

Observations of 14,286 cars in five mountainous grade locations from 2000 to 5000 ft altitude showed about 1% of the cars encountered running vapor lock.

Observations of 3450 cars on mountainous grades at 5000 to 7000 ft altitude showed less than 1% encountered running vapor lock.

At 10,000 to 13,000 ft, over a temperature range of 46 to 75 F, 1.45% of 205 cars encountered running vapor lock whereas 2.4% encountered vapor lock following soak.

• **Overheating causes stalling.**—Poor hot fuel handling characteristics are not the only cause of car stalling during midsummer months. Engine overheating can be a greater problem than vapor lock, particularly at high altitudes. Observations at altitudes between 10,000 and 13,000 ft revealed that 25.4% of 205 cars that stalled did so due to overheating. Ambient temperature was 75 F, and it appears logical that at higher temperatures the problem would increase.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members 60¢ to nonmembers.

LOW-FLOTATION SPACED TRACKS . . .

. . . appear to offer more promise of improvement in off-highway vehicle locomotion than does pursuit of conventional high-flotation principle.

Based on talk by **M. G. Bekker,** Lt.-Col., Canadian Army

Technical Director, Land Locomotion Research Laboratory, U. S. Army Ordnance Corps, Detroit Arsenal

RESEARCH in the mechanics of land locomotion suggests two paths toward vehicle improvement:

1. Propel the vehicle by shearing the soil not by the process implied directly in the Coulomb equation but by some other, more advantageous process of soil shear in which Coulombian process takes place in an indirect way. (Coulomb's equation expressing shear as a function of cohesion, pressure, and friction predicts tractive forces of conventionally designed off-highway vehicles.)

2. Design tracks and wheels to encounter less drag, bulldozing-type and compaction resistance.

Experimental results bear out these two indications. A track composed of cleats spaced a carefully determined distance apart does produce shear giving a much higher thrust than that produced by a conventional track shearing the soil according to the direct process assumed for Coulomb's equation. Besides, this spaced-link track has lower bulldozing resistance and also lower lateral drag than conventional track for the same sinkage; in certain types of soil, if properly designed, it may have less compaction resistance.

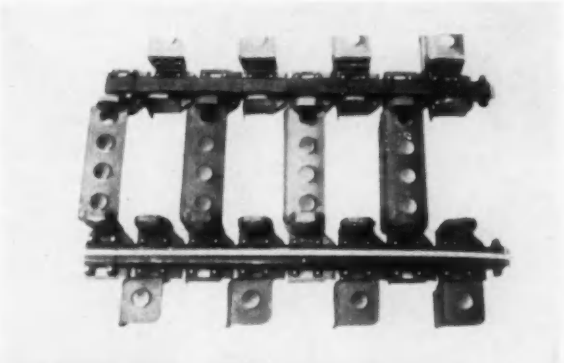
Five experimental vehicles have been equipped with the spaced-link track. One of them, the Groundhog, has doubled the thrust/weight ratio of ordinary vehicles in a variety of soil and snow conditions. Drawbar pull up to 180% of vehicle weight may be expected where conventional vehicles can pull only 75–95% of their weight.

A commercial agricultural tractor redesigned in Canada along the new theoretical principles also doubled its usual drawbar pull in a sandy soil and in snow. Although the spacing of track vehicles was compromised original weight and overall dimensions were preserved.

Widening conventional tracks beyond a certain width does not pay. But spaced-link tracks do not seem to have a width limitation; tracks extending the width of the vehicle are not only possible but also advisable. (They would, of course, require new power trains designed to fit the new configuration.)

The theory which led to the design of the spaced-link track is detailed in a book titled "Theory of Land Locomotion, the Mechanics of Vehicle Mobility" about to be published by the University of Michigan Press. The book will be eventually used in courses in land locomotion which have recently been considered in the automotive engineering curriculum of the University.

(Talk "Present State of Off-road Locomotion, and Its Future" was presented at SAE Southern California Section Seminar on Frontiers in Automotive Engineering, April 25, 1956.)



NEW TRACK HAS SPACED CLEATS which shear soil in manner different from shearing action of usual continuous series of cleats. Spaced cleats give much greater thrust and incur less resistance to motion in critical soils.

TREND Is Toward

Commercial ground vehicles will use both "pure" turbines and turbine-compounded piston engines in the future, SAE West Coast Meeting indicates.

TURBINE versus piston . . . Now that the question has been settled for air transport, it is beginning to be debated all over again for ground transport.

The question was pretty thoroughly aired at the SAE West Coast Meeting held August 6–8 at the Mark Hopkins Hotel in San Francisco.

In addition to the technical talk, the Meeting offered daily luncheons, a banquet, a display of special locomotive equipment; and a full day tour and cruise aboard the aircraft carrier, U.S.S. Bennington. Ladies accompanying members and guests to the Meeting were welcomed at a hospitality room maintained by wives of the local SAE section members. This spot served as headquarters for organizing shopping trips and visits to scenic spots in and around San Francisco.

The official opening of the West Coast National Meeting came as J. R. MacGregor, General Chairman of the Meeting, welcomed the group that had assembled not just from the West Coast but from all parts of the United States, Hawaii, and Canada. In his introductory remarks, he pointed out that in keeping with the theme of the Meeting—making the best use of and getting the most out of automotive equipment—efforts had been made to bring the manufacturers and users of automotive equipment together on common ground where they could discuss their individual needs and arrive at the most

HARD WORKING COMMITTEE that made the arrangements for this very successful meeting included (seated, left) W. G. Nostrand, Mrs. W. G. Brown, J. R. MacGregor, Mrs. J. R. MacGregor, W. G. Brown; (standing) J. C. Taber, J. F. Koehnle, B. E. Boswell, E. B. Lien, D. C. Wimberly, R. E. Van Sickle, and R. E. Jeffrey.

TURBINES

ON THE PROGRAM FOR THE BANQUET were L. B. Lundborg of the Bank of America, Meeting General Chairman J. R. MacGregor, and Toastmaster H. G. Vesper.

Speaking on the topic "Polish Up Your Mirror," Lundborg urged his listeners to take a good look at themselves as supervisors. Engineers who fail in their jobs, he said, usually fail not because of a lack of technical knowledge but because they don't have the ability to deal with others, particularly subordinates.

satisfactory solutions to their mutual problems.

The Meeting showed that in some instances a good case can now be made out for the turbine on the basis of lower fuel cost, space savings, or more favorable power-speed characteristics. In other instances, current interest in turbines stems mostly from a desire not to be caught napping if this relatively new type of powerplant proves advantageous over conventional types.

If there was any answer to be drawn from the turbine-versus-piston deliberations, it was probably that there will be a gradual shift toward the turbine, most likely toward hybrid piston-plus-turbine types as much as to pure turbine powerplants.

The Union Pacific Railroad, for example has been pioneering gas turbine locomotives on its Wyoming Division for four years. On the basis of 6,000,000 miles of service, the railroad finds its combustion type turbines (having 15-stage axial-flow compressors and can-type burners) well worth while.

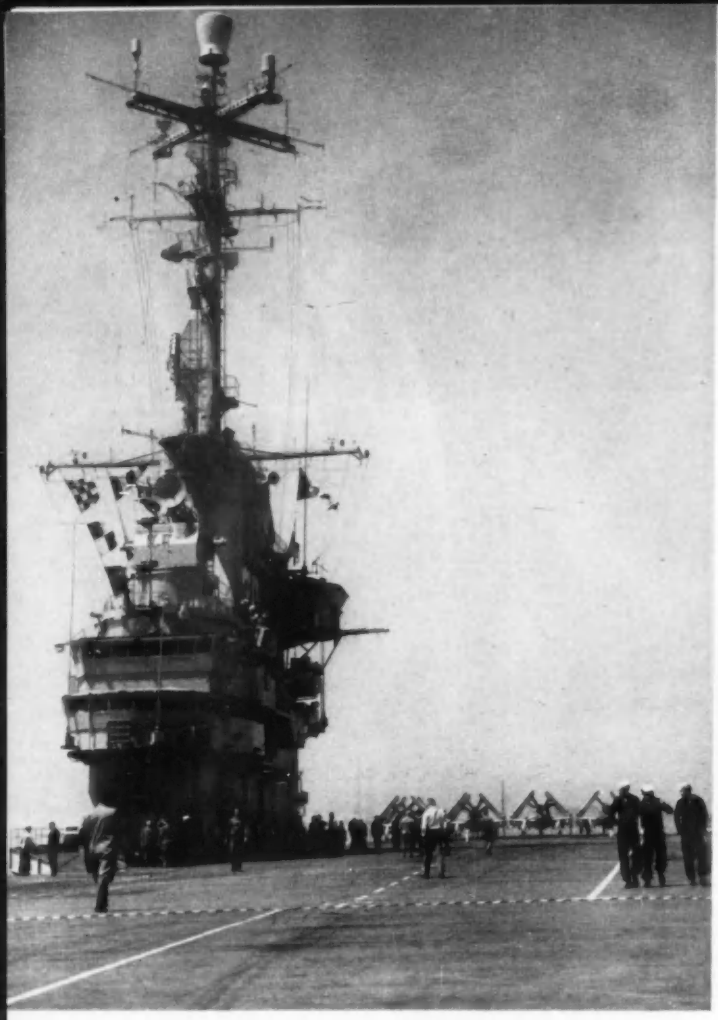
The same railroad, for the last year and a half, has been experimenting with adding turbines in the form of turbochargers to its two-cycle diesel locomotives operating between Omaha and the Pacific Coast. The turbochargers have centrifugal turbines powering centripetal compressors. Intercoolers cool the charge between the turbocharger outlet and the inlet of the engine's Roots-type blower.

The use of the two types of motive power by one railroad on different parts of its line points up one of the limitations of the turbine: It is confined to the relatively flat country because its power output deteriorates markedly at high altitudes—and also at high ambient temperatures.

The diesel engine also suffers from height and heat—but turbocharging can revive it.

Of course, the diesel compounded with the turbo-

SAN FRANCISCO CABLE CAR motif was used for registration booth. Altogether, nearly 450 members and guests registered—and despite the sightseeing attractions of the city, attendance at sessions ran as high as 400.



SAE WENT TO SEA

ON THE CARRIER BENNINGTON

EVEN after three days of technical sessions at the SAE West Coast Meeting, 170 of the Meeting participants arose in time to board Navy buses at the Mark Hopkins Hotel at 5:45 a.m. on Thursday, Aug. 9, to go out to sea for a day on the U.S.S. Bennington CV A-20.

Because of fog most of the day, they saw only two fly-offs from the Bennington's angled deck and no use of her mirror landing system. But they were treated to thorough demonstrations of launching and recovery equipment, fire fighting devices, and servicing and maintenance facilities.

Besides, the SAE members were guests of the Navy at a hearty breakfast, a heartier lunch, and a band concert. The trip took the ship under both the San Francisco and the Golden Gate Bridges and 35 or 40 miles out to sea.

Below:
BENNINGTON's commanding officer Capt. Robert E. C. Jones, USN, with SAE President George A. Delaney, Meeting General Chairman J. R. MacGregor, and Arrangements Co-Chairman William G. Nostrand.

chargers delivers all its power at the engine crankshaft.

The Meeting brought news of two types of piston engines compounded with turbines where the power comes not from the crankshaft but from the turbine. One was the free piston gasifier type of turbine powerplant. The other was the Orion family of engines.

The Meeting disclosed that General Motors has, besides the 250 gas hp GMR 4-4 Hyprex free piston engine unveiled at SAE Summer Meeting last June, a 1250 gas hp GM-14 unit for commercial power generation. (See "25,000 Hours of Free Piston Engine Operation" beginning on page 64.)

The GM-14, like the Hyprex, operates on the opposed piston two-stroke cycle. On the inward

Nob Hill Nuggets

brought to light at the SAE West Coast Meeting

Tires

Many 1957 cars will be using smaller diameter tires. Load ratings will be comparable, but tires will have larger cross-sections, 2 psi lower inflation, and 14 in. diameter rims. The inch or so saved will help lower car heights and give longer useable passenger space.

Conventional spare tires may go the way of the old-time running board tool box so that stylists can lower height of the rear deck. For emergency use, there may be a folded-up collapsible two-ply tire with spare wheel and CO_2 bottle for inflation.

Education and Industry

Prof. W. Paul of Oregon State College, speaking at the Monday luncheon emphasized that there is a large pool of university personnel that could be utilized in industry for short periods of time each year. He felt that the practice of some industries of organized programs for professors and teachers should be greatly expanded. Industries would profit by receiving fresh viewpoints and also, in the long run, by the fact that university personnel would develop better understanding of industrial problems and could better train students to handle these problems.

Fuels

Premium motor fuel of 108 octane number (AGAC) is possible on the basis of present petroleum technology. The processing developments that would make it possible would also improve stability of gasoline and reduce sulfur content of diesel fuel.

Truck Mufflers

Prime cause of muffler failures appears to be high temperatures. Mufflers run so hot normally that a small temperature increase, such as that caused by overloading the engine, rapidly decreases the strength of mild steel to the failure region. Ceramic coatings might help extend life of the mild steel.

Both lead and sulfur present in fuel seem to decrease service life of mufflers.

Discretion . . .

. . . is closing your eyes to a situation before someone closes them for you.

Hills, Hills, Hills

If you get tired of walking on San Francisco streets, you can always just lean on them, cracked V. C. Peterson of the San Francisco Municipal Railway in narrating his film "Gravitation vs. Transportation in San Francisco." Meeting participants who hiked back to the Mark Hopkins Hotel, where sessions were held, from Chinatown, Fishermen's Wharf, or the four-masted sailing ship Balclutha appreciated his meaning.

The movie "Severe Service with Heavy Duty Earthmoving Equipment" was narrated by Lloyd Pfeister of the Bechtel Corp., substituting for R. P. Ball. The movie "Timber on Wheels" was presented by R. W. Olin of Potlatch Forests, Inc.

All three movies were specially prepared for the Meeting to show certain distinctly West Coast transportation situations.

An Executive . . .

. . . is a man who goes around with a worried look on the face of his assistant.

stroke, air is compressed between the two pistons. Compression ignition occurs and the pressure forces the pistons apart. In moving outward, the pistons uncover exhaust ports emitting the exhaust through ducts to a turbine. The pistons, being double ended, also compress air on their outward stroke in "bounce" chambers at their outer ends. This compressed air furnishes the energy to return the pistons to their inner dead point when the open exhaust ports lower the pressure between the pistons.

Gas from the gasifier is at only 850 F when it goes to the turbine, much cooler than the turbine inlet temperature of combustion turbines. So the turbine materials problem is greatly eased.

Interesting point made about the free piston type is that although it runs on the diesel cycle, it is in-

. . . more Nob Hill Nuggets

Maintaining the Schedule

All during the Meeting, speakers and discussers were held to their time limits by a unique timing device. A full-size San Francisco city traffic signal was prominently displayed in the front of the session room. As long as speakers were within their allotted time it read "GO," but if they ran overtime it switched to "STOP," accompanied by a loud clang of the bell.

Thanks

SAE Journal is indebted to R. E. Van Sickle of the committee on the Meeting for many of the details and the photographs used in this report . . . and to H. L. Dickey for the photograph of the carrier deck.

Customers' Desires Versus Cost

The car manufacturer's problem is to strike a balance between what the customer wants and what he's willing to pay for—not just in initial cost but in other factors, too, philosophized SAE President George A. Delaney in a Wednesday luncheon talk.

In general, the customer won't expend any more driving effort, but he will spend a little more fuel for what he wants. For example, free wheeling faded from the competitive picture because it required cooperation from the driver to control the car. But automatic transmissions have been very popular despite the slight penalty imposed on fuel economy.

The manufacturers that strike the right balance are the ones that survive, Delaney pointed out. They create a double profit—the one that they reap and a profit for the customer, too.

People as Well as Equipment

Besides "getting the most out of automotive equipment"—the theme of the Meeting—transportation engineers should concern themselves with getting the most out of their people, declared banquet speaker L. B. Lundborg of the Bank of America.

The good supervisor is sensitive to the feelings of his subordinates. He recognizes that they want to know where they stand. If a worker is doing a good job, the boss tells him so.

As automation displaces workers from the jobs they have been performing, supervision must be especially sensitive to workers' fears stemming from reversals of roles and personal relationships, Lundborg warned.

Brakes

Steady brake application is better than snubbing to slow a vehicle descending a hill. The total energy to be absorbed is the same for intermittent snub or steady drag braking. But the *rate* of braking is higher for snubbing. Therefore, lining and shoe interface temperatures reach higher values, at least momentarily, where wear is more rapid. Cooling between snubs is negligible.

Thanks also to . . .

Session Secretaries: John Conti, City Motor Co.; Dwight T. Hume, Ernie Majer, Inc.; R. A. Hundley, Wetmore Hodges and Associates, Inc.; W. L. Kent, Union Oil Co. of Calif.; M. W. Savage, California Research Corp.; and T. S. White, General Metals Corp.

Session Chairmen: B. T. Anderson, Union Oil Co. of Calif.; C. A. Hancock, Shell Oil Co.; W. A. Hubbell, Standard Oil Co. of Calif.; E. J. McLaughlin, California Research Corp.; A. D. McLean, Kenworth Motor Truck Co.; and J. L. Peters, Cummins Diesel Sales, Inc.

PAST - PRESIDENT WITH TWO VICE-PRESIDENTS: 1955 SAE President C. G. A. Rosen poses with T. M. Robie, current vice-president representing the SAE Diesel Engine Activity, and Julius Gaussoin, vice-president representing the SAE Transportation and Maintenance Activity.

sensitive to cetane rating as well as to octane rating. It apparently runs equally well on 100 octane gasoline, kerosene, diesel fuel, Bunker C, or crude oil. Only noticeable effect is that power output varies with heat content of the fuel used.

Reason that cetane rating is of no concern to the free piston engine is that combustion chamber temperatures are very high—high enough to ignite fuels that would be impossible to ignite in conventional diesel combustion chambers.

Reason that detonation is no problem with the free piston engine is that the pistons really are free to give the combustion processes the room they need. Extreme gas pressures don't get a chance to build up in this type of variable-stroke engine.

A corollary to the "freedom" of the pistons is the absence of the connecting rods and crankshaft—which brings freedom from the bearing problems of crankshaft engines. Of course, the free piston engines are not without their own problems, as the GM Research men pointed out. But they have succeeded in surmounting the problems they have uncovered so far.

The Orion principle is to use the crankshaft power output of a diesel engine to power two centrifugal compressors, one which supercharges the cylinders and the other which furnishes cooling air. Discharge from both compressors eventually enters the turbine, which develops the useful power.

The Orion engines were a project General Electric undertook in 1950 for Army Ordnance for application to tanks and other tracked vehicles. The project was discontinued at the end of 1955. But GE had by then built and studied three small experimental engines, the Alpha, Beta, and Gamma—all named for stars in the Orion constellation—and the full-scale Rigel—named for the bright star in the knee of Orion.

The advantage of the Rigel is its high power/volume ratio. The 600-hp package is only 35 in. high by 47 in. wide by 67 in. long. It operates on diesel fuel.

Although the engine is not now aimed for actual use in vehicles, it is another indication of the direction away from pure piston engines toward turbine power that vehicle powerplants may take.

Papers presented at the SAE National West Coast Meeting, San Francisco, Aug. 6-8, 1956

J. D. Bennett
Fawick Brake Division, Fawick Corp.
"Modern Efficient Brake Systems for Trucks and Busses (For Both Service and Emergency Brake Requirements)"

Gregory Flynn, Jr.
General Motors Corp.
"Observations on 25,000 Hours of Free Piston Engine Operation"

R. C. Hill
Union Pacific Railroad Co.
"Railroad Experience With a Turbo-Charged Two-Cycle Diesel Engine"

R. C. Hill
Union Pacific Railroad Co.
"Six Million Miles Experience With Gas Turbine Locomotives"

W. M. Holaday
Deputy Assistant Secretary of Defense (Research and Development)
"Fuel for Thought"

R. J. Hooker
General Electric Co.
"'ORION'—A Gas-Generator, Turbo-Compound Engine"

P. S. Myers, P. C. Rosenthal, O. A. Uyehara
University of Wisconsin
W. Chow, Sparton Automotive Co.
C. E. Nelson, Nelson Muffler Co.
"Truck Mufflers—Temperatures, Materials and Life"

G. L. Neely, E. F. Griep, P. L. Pinotti
Standard Oil Co. of California
"Dark Diets for Diesels"

J. G. Oetzel
Warner Electric Brake and Clutch Co.
"Better Truck and Bus Brakes"

R. P. Powers
Firestone Tire and Rubber Co.
"Tires and Horsepower"

C. G. A. Rosen
Consulting Engineer to the President, Caterpillar Tractor Co.
"An Economic Analysis of The Internal Combustion Engine Field"

W. T. von der Nuell
AiResearch Industrial Division, The Garrett Corp.
"Notes on a Turbo-Charged Two-Cycle Diesel Engine"

Complete copies of these papers are available in multilith form from SAE Special Publications Department. Price: 35¢ each paper for members; 60¢ each paper for nonmembers.

Section Meetings

BALTIMORE

October 4 . . . AOA Show-Aberdeen.

BRITISH COLUMBIA

September 24 . . . Speaker **W. G. Nostrand.** Hotel Georgia.

CENTRAL ILLINOIS

September 24 . . . D. M. Heller, director of engineering, Missile Section, Bendix Aviation Corp., South Bend, Ind.—"A Survey of Guided Missile Status." Pere Marquette Hotel. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Features: Coffee Speaker Topic: "Your Rights if Arrested."

CLEVELAND

September 17 . . . Mr. Croft.—"The Traffic Control Problems of the Cleveland Airport." NACA Laboratories. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Features: Preceding the dinner, there will be a tour of Cleveland Hopkins Airport, starting at 4:00 p.m.

DETROIT

October 8 . . . Panel Meeting—Three Speakers: **Donald Frey,** associate director, Scientific Lab., Ford Motor Co., **George J. Huebner, Jr.,** executive engineer, Research, Chrysler Corp., **D. F. Caris,** head, Automotive Engines Department, General Motors Research Staff, GMC.—"Engines for the Car of Tomorrow." Rackham Educational Memorial. Dinner 6:30 p.m. Meeting 8:00 p.m.

INDIANA

September 20 . . . Gregory Flynn, Jr., assistant head, Mechanical Development Department, General Motors Research Staff, GMC.—"The General Motors Free Piston Engine." Naval Armory Mess, 30th Street & White River, Indianapolis. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Social Hour 6:30 p.m. Sponsored by Perfect Circle Corp.

METROPOLITAN

October 4 . . . Victor G. Raviolo, director, Advanced Product Study & Engineering Research Office, Ford Motor Co.—"What the Future in Automobile Design Means to Petroleum Technologists." The Brass Rail Restaurant, 43rd Street & Fifth Avenue, New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

MILWAUKEE

September 14 . . . Golf Date
October 5 . . . James M. Smith, head, Automotive Engine Section & **Richard M. Smith,** engineer, Aluminum Company of America, Cleveland, Ohio. — "Aluminum Engines — Design Problems & Their Solutions." Milwaukee Athletic Club. Social Hour 6:00 p.m. Dinner 6:30 p.m. Meeting 8:00 p.m.

NEW ENGLAND

October 2 . . . Nelson R. Brownyer, vice president, Timken Detroit Axle Division, Rockwell Spring & Axle Co., Detroit.—"Engineering Development & Operation of the New Timken Detroit 'Wide Range' Double-Reduction, 2 Speed, Driving Axles, in Modern Over-the-Road Vehicles." M.I.T. Faculty Club, Cambridge, Dinner 6:45 p.m. Meeting 8:00 p.m.

NORTHWEST

October 12 . . . Max Tauschek, chief engineer, Valve Division, Thompson Products Co.,—"Valves & Tappets." Stewart Hotel.

PHILADELPHIA

October 10 . . . Dr. Herman Epstein, director, Research Department, Burroughs Corp., Paoli, Pa.—"Computers." Engineers Club of Philadelphia. Dinner 6:30 p.m. Meeting 7:45 p.m.

SOUTHERN NEW ENGLAND

October 2 . . . Donald G. Sturges, manager, New Products Branch, Research & Development Division, Carborundum Co., Niagara Falls, N. Y.—"Industrial Applications of Nuclear Energy." Bradley Field, Windsor Locks, Conn. Dinner 6:45 p.m. Meeting 8:00 p.m.

ST. LOUIS

October 9 . . . J. B. Franklin, vice president, Operations & Maintenance, Capital Airlines, Inc., National Airport, Washington, D. C.—"The Capital Airlines' New Viscount."

SAN DIEGO

October 9

SYRACUSE

October 9

TEXAS

September 14 . . . Subject: "Automotive Air Conditioning." Amon Carter Airport. Dinner 6:30 p.m. Meeting Afternoon & Evening. Special Features: Exhibits on Truck, Bus, Car, Boat & Tractor Air Conditioning.

TEXAS GULF COAST

September 14 . . . Speaker from Fram Corp.—"Oil & Air Filtration as Applied to Automotive Equipment." Varsity Room, College Inn. Dinner 6:30 p.m. Meeting 7:30 p.m. Special Features: Cocktails 6:00 p.m.

TWIN CITY

September 13 . . . 1956 SAE President George A. Delaney, chief engineer, Pontiac Division, GMC.—"Designing an Automobile." Hasty-Tasty Restaurant, 1433 W. Lake St., Minneapolis. Dinner 6:45 p.m. Meeting 7:45 p.m.

VIRGINIA

September 24 . . . William Byrd Hotel

WILLIAMSPORT

October 1 . . . A. R. Bobrowsky, supervisor, Applied Sciences, Ford Motor Co., Dearborn. — "Free Piston Gas Generator Development." Moose Auditorium, Williamsport. Dinner 6:45 p.m. Meeting 8:00 p.m.

SECTIONS

SEPTEMBER 1956

South Texas Newest Group

SAE South Texas Group comes into being on October 1, the start of the Society's fiscal year, as a result of Council action at its June 7 meeting. The new Group results from Council's favorable action on the petition of the South Texas Division of the SAE Texas Gulf Coast Section for recognition as the SAE South Texas Group.

Texas Gulf Coast Section endorsed the Division's petition and has ceded 51 Texas counties for attachment to the new Group.

In taking action to recognize the Division as a new Group separate from the Texas Gulf Coast Section, the Council and the Sections Committee Executive Committee took into consideration the growth and accomplishments of the Division as well as the guidance and help it has received from the Texas Gulf Coast Section.

An SAE Group differs from a Section in that it is authorized on a year-to-year basis, and is not represented on certain of the Society's committees, such as, the Annual Nominating Committee, the Sections Committee, the Membership Committee, the Student Committee, and the Placement Committee.

Fred W. Biederman (left), past-chairman of the Cincinnati Section, accepts the Past-Chairman's Certificate from Owen L. Negandard, the newly elected chairman.

SECTION SHORTS

Indiana Section Reception Chairman **Jake Wellman** plans during the 1956–1957 year to introduce all new members and transfers at their first meeting. He requests that these members contact him and let him know when they are arriving.

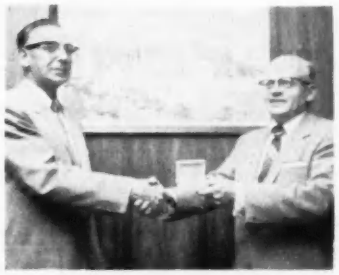
Plant Representatives will be appointed for the first time during the 1956–1957 Section year. Membership Chairman **Bob Highland** will welcome all recommendations from Section members.

Indiana Technical College Student Branch members visited the Cincinnati Milling Machine Co. for an inspection tour on June 29. The 30-man group was shown all phases of the machine tool industry, including engineering and production. H. A. Macklin of the college's Mechanical Engineering Department was faculty moderator for the trip.

The student Branch called on an SAE member and school alumnus to be the guest speaker at its Annual Spring Banquet. **James W. Shank**, of Chrysler Corp. (ITC '37), spoke on automotive body engineering.

★ ★

The first meeting of the **Williamsport Group** will be held on Sept. 10. All subsequent meetings are to be held on the first Monday of each month. Vice-Chairman **Frank W. Riddell** is to be in charge of arrangements.



Warren G. Brown (left) outgoing chairman of **Northern California Section**, is presented with the past-chairman jeweled tie clasp and cuff links by **Elvin B. Lien**, 1956–1957 chairman. This award insignia has been innovated recently by the Section. Brown also received a certificate from the SAE Council citing his leadership of the section during 1955–1956.

★ ★

Baltimore Section suggests something new in social events. An outdoor sports car showing at a meeting last year followed by dinner and dancing proved most successful. The auto show featured some old cars and trucks to illustrate automobile progress.

★ ★

Philadelphia Section Student Activity Chairman **Karl F. Green** has arranged the annual Student Night Meeting which will be held on November 14.

About SAE

Vickers

Gardiner

Moncher

Mortenson

Siers

Hall

Heath

Swan

HARRY F. VICKERS, founder of Vickers, Inc., was the commencement speaker at the University of Southern California in June. He also received an honorary doctorate, being made a Doctor of Science.

Vickers is now vice-chairman of the board of Vickers, Inc., and president of the Sperry Rand Corp. of which Vickers is a division.

DUNCAN GARDINER has been named director of research and development for Vickers, Inc.

Gardiner will be responsible for research and development programs which supplement the development activities of the Vickers product groups. Prior to receiving this new assignment, he had been assistant chief engineer.

FRANK L. MONCHER has been appointed chief engineer—airborne products, Detroit, of Vickers, Inc. In his new position, Moncher will be responsible for design, development, and test of aircraft type oil-hydraulic pumps and motors as well as complete airborne hydraulic systems.

PAUL C. MORTENSON has joined Vickers, Inc. as chief engineer—ground mobile products. Prior to joining Vickers, he was administrative engineer, Western hemisphere, Massey-Harris-Ferguson.

Mortenson will be responsible for development, design, and test operations of three separate product line subgroups within the ground mobile product classification.

A. F. SIERS has joined the Air-Maze Corp. as a factory representative. Siers, who will handle special accounts in Ohio and Michigan, was formerly chief engineer of Twin Coach Co., Kent, Ohio.

FRED P. HALL, JR., a veteran of 42 years' service with Dana Corp. and predecessor companies, has retired.

Hall started work in the factory of Salisbury Axle Co. immediately after being graduated from Cornell University. In 1918 he became chief engineer at Salisbury. The firm became a division of Dana Corp. in 1919. He was made manager of the Axle Division when the operation was moved to Toledo in 1929.

W. C. HEATH has been named to the newly created post of projects manager in Solar Aircraft Co.'s San Diego plant, Herbert Kunzel, president, has announced.

Reporting directly to the plant manager, Heath will undertake major projects and will be responsible for coordinating activities pertaining to them among the various company divisions. Initially, Heath will be concerned mostly with the Jupiter T-300 gas turbine program now approaching full-scale production.

Heath has been with Solar since 1937, becoming chief engineer five years later and executive engineer—marketing in 1955.

He was chairman of the SAE San Diego Section in 1950, of the San Diego Section of IAS in 1951, and of the San Diego Section of ASME in 1955. He was an SAE Councilor in 1954 and 1955 and is currently vice-chairman for meetings of the SAE National Aircraft Powerplant Activity Committee.

ROBERT SWAN has been appointed western sales manager of Buck Manufacturing Co. He was assistant sales manager of the Engine and Gear Division, Hall-Scott Motors Co. before joining Buck.

Swan will be in charge of dealer sales in the 11 western states for the company's Bux brand portable electromagnetic drill presses, vises, and plate clamps.

DR. NORTON B. MOORE has joined Aerophusics Development Corp. as a staff engineer. He has been operating his own consulting service, and prior to that he was affiliated with the McDonnell Aircraft Corp. as chief engineer, guided missile and propulsion divisions.

WALTER E. STEWART has been appointed general superintendent of the Lake Street tractor plant, Minneapolis-Moline Co. He had been manager of industrial engineering for Cleveland Graphite Bronze Co.

DONALD S. McARTHUR has been named supervising engineer of a newly formed section in the Economics Division of the Esso Research and Engineering Co., Linden, N. J. He had been head of the applied mathematics group, Products and Research Division of Esso.

MILTON J. THOMPSON, professor of aeronautical engineering and associate director, Defense Research Laboratory, University of Texas, has been made a fellow of the American Society of Mechanical Engineers.

RAYMOND T. LEWIS, who was manager, Light Metals Division, Thompson Products, Inc., has been made president and general manager, Cloyes Gear Works, Inc., Cleveland.

WILLIAM K. PARK has been transferred from Central region to the Eastern region as an account manager for Petroleum Chemicals Division, E. I. du Pont de Nemours & Co. His headquarters will be in New York City.

Members

Christie

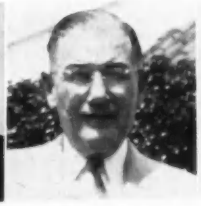
Hinchcliffe

Angst

Herdrich

Larson

De Cenzo



W. T. Miller

Buck

CLIFFORD M. LARSON, chief consulting engineer, Sinclair Refining Co., New York, has retired. Larson, with Sinclair for 37 years, will go into private practice as a consulting engineer. His new address is Larcliff, 55 Taymil Road, New Rochelle, N. Y.

During World War I, Larson served as lubrication engineer in the Signal Corps. Upon discharge from the Army, he joined Sinclair as assistant supervising engineer in charge of staff and lubrication engineers. In 1937 he was made chief consulting engineer.

During World War II he served as expert consultant to Secretary of War, covering fuels and lubricants problems. He is also the inventor of several viscosity measuring instruments.

Larson served as chairman of SAE Placement Committee from 1947 to 1953, has been a member of the Fuels and Lubricants Committee since its initiation in 1926, and has read many technical papers before the society.

HERB DE CENZO, previously chief engineer with E. B. Wiggins Oil Tool Co., Inc., has been made chief engineer of the newly established coupling division of On Mark Engineering Co. of Glendale.

WALLACE T. MILLER, president and chairman of the board of NTH Products, Inc., has announced plans for a $100,000 plant at Gillespie Field, San Diego, Calif. The site is the present location of a company machine shop. The new 30,000-square-foot building will house extruding works and welding and forming machinery.

Miller has been president of NTH since late in 1955. Previously he had been assistant to the president, Bardwell and McAllister, Inc., Burbank, Calif.

He began in industry as chief accountant of the Willys-Overland Co. and has held many responsible positions, including general sales manager, Motor Wheel Corp., Lansing, Mich.

JOHN P. BUCK has been made vice-president in charge of manufacturing at Maremont Automotive Products, Inc. Buck joined Maremont in 1940 as a field engineer. Through a series of promotions he became plant manager of the Harvey, Ill. factory in 1946. In 1950, he assumed additional duties covering muffler engineering as well as manufacturing.

CLIFFORD F. HOOD, president of United States Steel Corp., was elected chairman of the newly-created executive committee at U. S. Steel.

CHESTER D. CHRISTIE, staff engineer with the Axle Division of Eaton Manufacturing Co., has been appointed assistant chief engineer. He becomes the second assistant chief engineer on the Axle staff.

H. L. HINCHCLIFFE has been made manager, head office marketing operations, of Shell Oil Co. of Canada, Ltd.

He was formerly manager distribution, head office. He joined Shell in 1932 at the Montreal East Refinery.

W. D. ANGST, formerly manager of the Detroit Plant of Thompson Products, Inc. of Detroit, has been made manufacturing manager of the Michigan Division of the company comprising three plants.

Angst joined Thompson in 1942 in Cleveland. He progressed through the organization in Cleveland before his transfer to the Michigan Division in 1950 as assistant factory manager at Detroit. He later was made industrial engineer for the division and became plant manager at Detroit.

HAROLD E. HERDRICH had been made director of master planning for Northrop Aircraft, Inc.

Prior to his new appointment, Herdrich was staff assistant to the president. He previously was assistant manager of industrial and plant engineering.

JOSEPH J. HITE, formerly chief engineer, American Hoist & Derrick Co., has been named director of engineering of the company.

KENNETH F. POTTER, who was assistant chief engineer at American Hoist & Derrick, has been made chief mechanical engineer.

E. F. TOMLINSON has been elected president of the B. F. Goodrich Tire Co., a division of the B. F. Goodrich Co. He has been vice-president, Equipment Division, of the Goodrich Tire Co. since 1953. He joined Goodrich in 1927 in a sales capacity.

KEMPTON H. ROLL has been appointed to the newly created position of executive secretary and treasurer of the Metal Powder Association. He had been technical director at the association.

LEON C. GREENEBAUM has been elected chairman of the board of the Hertz Corp., Chicago. He has been vice-chairman of the board since February, 1955. Previously, he had been president of Metropolitan Distributors, Inc., which was acquired by Hertz in 1954.

CARL HALPIN has been appointed manager of engineering at Ross Operating Valve Co. Formerly, he was president of the F. L. Jacobs Co., Detroit.

Chrysler Executive Changes

Row Zeder Ackerman Bright Newberg

EDGAR C. ROW has been named administrative vice-president of Chrysler Corp. Row's appointment to this position, new at Chrysler, places him second in authority to Chrysler president **L. L. COLBERT**, who made the appointment. Previously Row had been president of the company's Export Division, and earlier, president of Chrysler Corp. of Canada.

JAMES C. ZEDER has been named special adviser to the president, Chrysler Corp., and continues as a member of the Chrysler board of directors. Preceding his new appointment, Zeder had been vice-president—engineering. He was president of SAE in 1950.

PAUL C. ACKERMAN recently named director of engineering at Chrysler, has now been made a vice-president of the corporation.

RINEHART S. BRIGHT has been named Group vice-president—basic manufacturing, and a director of the company. Bright has been vice-president of the Dodge Division and was previously general manager of the company's Indianapolis transmission plant.

WILLIAM C. NEWBERG has been named Group vice-president—automotive. He has been with Chrysler for many years, most recently as president of its Dodge Division.

W. ARCH BRYCE, formerly director of the Division of Public Safety, University of Toronto, has been named general manager of the Canadian Highway Safety Conference.

WILLIAM B. SHIMER has been appointed chief industrial engineer for the De Soto Division of Chrysler Corp. In his new position, Shimer will be responsible for all supervision of the master mechanic, time study, and cost estimating departments.

KEITH H. RHODES, previously a design engineer with the Buda Division of Allis-Chalmers Mfg. Co., is now a design engineer with American Motors Corp.

EDWARD B. NORTHUP, formerly a lighting and optics engineer with the Ford Motor Co., is now an optics engineer in the Physics Research Department of the Chrysler Corp. in Detroit.

STEVE A. BEISERT, a former partner in Martin's Radiator Works is now president of the Martin-Pivo Corp. of Los Angeles. The company deals with the manufacturing and repairing of automotive and industrial radiators.

A. T. COLWELL, SAE past-president, and vice-president of Thompson Products, Inc., Cleveland, made this forecast in a recent banquet address at the semiannual meeting of the American Society of Mechanical Engineers:

"Gas turbine-powered automobiles will be coming off the production lines as present production equipment requires replacement. . . . Fuel injection systems for piston engines will come even before the gas turbine. . . . Changes in suspension systems are 'right around the corner.' . . . America's highway system will expand rapidly to rival anything the world has ever known. . . . Municipal parking and traffic problems will be solved by the complete elimination of on-street parking and the establishment of peripheral parking lots."

RICHARD M. JONES is now project engineer, Racing Division, Champion Spark Plug Co. He had been sales engineer, McCulloch Motors Corp.

J. A. FERTNIG, formerly a service engineer with A. R. Palit & Co., Ltd., is now a service engineer with Voltas Ltd., Calcutta, India.

ALEXANDER O. FOX has been elected to the board of directors of McNeil Machine & Engineering Co., Akron, Ohio. Fox is the former president of Lincoln Engineering Co. of St. Louis, now named Lincoln Engineering Co., Division of McNeil Machine & Engineering Co.

CARL H. MUELLER, former vice-president of engineering with Lincoln, will remain in charge of this department as director of engineering.

WILLIAM A. BLUME has been promoted to executive vice-president of Gemmer Manufacturing Co., Detroit. Formerly vice-president in charge of sales, Blume joined Gemmer in 1953. He previously held the positions of president of American Brakeblok Division, American Brake Shoe Co.; president and director of Asbestos Mfg. Co.; and vice-president of American Brake Shoe Co. and Thermoid Co.

JEAN BORDEAUX, JR. has been made general manager of Supply and Service Hardware, Inc. of Canyonville, Ore. Previously, Bordeaux was manager, product development section of R. M. Hollingshead Corp., Camden, N. J.

LYMAN A. WINE, vice-president of the Electric Auto-Lite Co., was elected to the company's board of directors recently. He joined Auto-Lite in 1942 as sales manager of the Auto-Lite Lamp Division in Cincinnati. Before his appointment as vice-president, Wine served in the executive post of assistant to the president.

F. P. HEALY has been made vice-president and chief engineer for Van Norman Automotive Equipment Co., a newly formed subsidiary of Van Norman Co. He had been chief engineer, Automotive Equipment Division of Van Norman.

MELVILLE G. KENNEDY, previously vice-president, Ferro Stamping Co., has been named vice-president and sales manager, Automotive Spring Corp., Detroit.

OSCAR A. ESKUCHE is now a mechanical engineering consultant with Stulen Engineering Co. of Caldwell, N. J. He was an industrial engineer with Piasecki Helicopter Corp., Morton, Pa.

ELDEN H. OLSON has been appointed director of engineering, Aeronautical Division, Minneapolis-Honeywell Regulator Co.

Olson previously was chief engineer in charge of engine control systems and components at Minneapolis-Honeywell.

CARLOS A. CLAURE, previously a design engineer with Minneapolis-Moline Co., is now a mechanical engineer with Yacimientos Petroliferos Bolivianos Co. in Lapaz, Bolivia, S. A.

MAJOR WALTER E. RAFERT, previously at the Command and General Staff College, Fort Leavenworth, Kansas, is now instructor, armament engineering Department of Ordnance, United States Military Academy.

W. EDGAR MULHOLLAND has joined the Formsprag Co. as executive sales engineer and special representative to the automotive industry. Mulholland had been sales manager for the Magnus Products Corp., Detroit.

BERNARD H. HERSHKOWITZ, previously project engineer at Titeflex, Inc., Newark, is now assistant director of research, The B. G. Corp., Ridgefield, N. J.

ARTHUR M. BREWER is now a sales engineer with Fabsteel Sales and Engineering Co., Hazel Park, Mich. He had been a sales engineer with Automotive Rubber Co., Inc., Detroit.

STANLEY A. KAYE, formerly sales manager with Cardinal Mfg. Co., a subsidiary of Robin Products Co., Detroit, has been made sales manager of Robin Products.

WILLIAM C. DUNN, chairman of the board and co-founder of the Ohio Crankshaft Co. receives the Trinks Award for pioneering in induction heating from Dr. W. Trinks (right), while Dr. John C. Warner looks on. Dunn, who developed the basic patent for induction hardening of crankshaft surfaces, was one of four leading industrialists cited in the national industrial heating competition at Pittsburgh recently.

R. F. BURRIS, previously an automotive engineer with Pacific Intermountain Express Co. of Denver, is now a test engineer with Kenworth Motor Truck Co., Seattle.

RICHARD L. FLESHMAN, formerly a district engineer with United States Rubber Co., is now assistant commodity sales manager with U. S. Rubber.

ANTHONY B. KUBALA has joined Associated Designers, Inc., Birmingham, Mich. as manager and chief tool engineer at the company's newly opened Cleveland office. Kubala had been with Thompson Products, Inc. as design supervisor.

O. J. SMITH is an automotive sales engineer for Sutton Ford Inc. He had been president of Auto Rental & Leasing Co., Gulf Coast Rent-A-Car Truck Co. Inc., Houston.

J. DEAN GARRETT, formerly district sales manager, Thompson Products, Inc., is now administrative manager, commercial pistons, at Thompson.

K. H. KNOX has joined Weston Hydraulics, Ltd. a subsidiary of Borg-Warner Corp., as engineering sales manager. He had been manager, Aircraft Hydraulics Division, Parker Aircraft Co.

HARLEY W. HARRIS is now Cleveland branch manager of Reo Motors, Inc. Previously he was general manager, Autocar Division, White Motor Co.

SIR WILLIAM ROOTES, chairman of Rootes Motors Inc., and chairman of the British Motor Manufacturers, was one of the visiting executives at the International Automobile Show.

IRVING FRAZEE, former assistant national service manager, Ford Motor Co., and technical writer and editor of Service and Technical Publications, is one of the authors of two books recently published by the American Technical Society of Chicago.

The one is a new volume entitled: "Automotive Brakes and Power Transmission Systems." It covers the "how" and "why" of brake and transmission systems operation, maintenance, and repair.

The other is a newly revised edition of "Automotive Electrical Systems." It presents a thorough ground work of electrical theory, which is then applied to the automobile. It also covers trouble-shooting procedures for the various circuits and appliances in the electrical systems.

CARL EDWIN CLARK is now an assistant project engineer with Hamilton Standard Division of United Aircraft Corp. He had been electrical engineering group leader of National Airlines.

MARTIN RONNING, chief engineer of research, Minneapolis-Moline Co., was the recipient of the Cyrus Hall McCormick gold medal presented to him at Roanoke, Va., by the American Society of Agricultural Engineers.

ARTHUR J. SCAIFE, SAE president in 1932, was the subject of a feature story which appeared in the June 3 edition of the St. Petersburg Times. The story is entitled "Scaife Made History in Auto Industry" and is bylined George Bartlett.

The article noted that Scaife, who is now retired and a resident of St. Petersburg, has contributed much to automotive science as well as to the general history of our country. The article also noted that:

Scaife, a native of England, spent his boyhood in Ohio, taking his first job in the automotive field as an apprentice tool and die maker.

This first job led to an association with Rollin White, which in turn let Scaife in on the "ground floor" of the auto industry. He started as a tester and for many years after had charge of all the company's testing.

From 1902 to 1908 Scaife took part in many amateur contests in auto racing. Among them were the Automobile Club of America's "Reliability Contest," in which he chalked up a perfect score, and the first Glidden Tour, in which he scored a perfect race in the Ligonier Mountain test of the tour.

In 1940 Scaife joined the U. S. Army as a civilian consulting engineer. In 1945 he was transferred to the Quartermasters Department and remained there until he retired in 1949.

ARTHUR J. WILLIAMSON has been promoted to executive vice-president of Tube Reducing Corp., Wallington, N. J.

Williamson joined Tube Reducing in 1951 as vice-president. He had previously served as a plant manager of Summerill Tubing Co.

JOHN F. LEAMON, formerly master engineer, power plant engineering service, Trans World Airlines, has been made supervisor of the power plant for Trans World Airlines.

LT. COL. ROBERT G. BLAYLOCK, formerly Commanding Officer, Tokyo Ordnance Depot, has been made chief, Technical Intelligence Branch, Intelligence, Security, and Safety Office, Washington, D. C.

WILLIAM B. PROSSER, vice-president and general manager, Perfect Circle Corp., has been elected to the company's board of directors.

Prosser

ALBERT RESNICK, formerly a design engineer with Fruehauf Trailer Co., has been assigned as a project engineer, containers, with Fruehauf.

JAMES STEPHEN, who was a sales engineer with Fruehauf, has been assigned as a project engineer, field surveys, for the company.

JAMES O. YULE, previously test engineer, pollution abatement, Bethlehem Steel Co., is now systems engineer, RCA Service Co., Inc., Tucson.

WALTER H. NOFFKE is now senior production design engineer with Lockheed Aircraft Corp. He had been manufacturing research engineer with Lockheed.

R. L. OVERCASH, who was supervisor of the automotive laboratory, Kendall Refining Co., is now project engineer with American Viscose Corp.

EDWARD D. SPICER, previously senior technical writer, Ford Motor Co., is now supervisor, dealer service management unit, Tractor and Implement Division, Ford Motor Co.

ARTHUR S. SCHUTZER is now a field engineer with Wright-Aeronautical Division, Curtiss-Wright Corp. He was an instructor at Chanute Air Force Base, Rantoul, Ill.

ERNST W. PORTMANN, previously technical service engineer with General Tire & Rubber Co. of Canada Ltd., is now assistant to the general manager at the Marion Division of General Tire.

WILLIAM C. McKENNA, JR. has been named president and treasurer of the Diamond T Truck Sales Co., Baltimore. Formerly, he had been service manager, Warner Fruehauf Trailer Co.

McKenna served as SAE Baltimore Section Membership Committee chairman in 1952–1953, Section treasurer in 1954, and Section secretary in 1956.

J. STEWART MUNRO has been appointed president of the Canadian Co., Raybestos-Manhattan, Inc. He joined Raybestos-Manhattan in 1941 as plant engineer and has held the positions of chief engineer, assistant general manager, and vice-president.

HERBERT N. REITZ, JR. has been made senior project engineer at the Hamilton Standard Division of United Aircraft Corp. He had been assistant to the engineering manager at Hamilton.

NILAL S. P. NAIDU is now flight test observer and analyst with Blackburn & General Aircraft Ltd., Brough, E. Yorks, United Kingdom. He had been stressman, Handley Page, Reading, Berks, United Kingdom.

DR. C. W. GEORGIE, director of research, Quaker State Oil Refining Corp., has been elected a vice-president of the company.

E. E. EBNER, general superintendent of refineries at Quaker State, was also elected a vice-president of the company.

TERRY W. KUHN, executive vice-president, Bohn Aluminum & Brass Corp., has been elected a vice-president of Copper & Brass Research Association.

ROBERT F. KLEIN is a quality engineer with International Business Machines Corp. Previously, he had been a production specialist at Redstone Arsenal, Huntsville, Ala.

FLOYD G. LAWRENCE, former manager of publicity, Packard-Clipper Division, Studebaker-Packard Corp., has been appointed executive editor of Ward's Reports, Inc.

FOSTER N. PERRY has been appointed special representative in the United States for Robert Bosch, GmbH, Stuttgart, Germany. Perry was associated until recently with American Bosch Arma Corp., Springfield, where he served in various capacities for 32 years. His last 15 years at American Bosch were as a vice-president, the last 5 as executive vice-president.

WALTER D. McKINLEY, previously project engineer Titeflex, Inc., has been appointed secretary-treasurer, Timely Technical Products, Inc., Whippany, N. J.

W. WAITS SMITH has been elected vice-president of Westinghouse Electric Corp. He has been manager of the company's Aviation Gas Turbine Division at Kansas City, Mo., for three years, and will continue to direct that operation.

Smith began in the automotive field in 1925 on the engineering staff of Studebaker Corp. At the start of World War II, he was named chief engineer of Studebaker's Aviation Division until, in 1942, he went to Wright Field as a captain in the Air Force. He returned to Studebaker after the war and became chief administrative engineer for both gas turbine contracts and the Automotive Division, a position he held until he joined Westinghouse.

Smith

ERVIN C. LENTZ, JR. is now development engineer, fuel injection, Sparton Automotive Division of Sparks-Withington Co. He was research engineer, Ford Scientific Laboratory, Ford Motor Co., Dearborn, Mich.

DAVID D. CARRINGTON, has been made assistant to the chief engineer of Walter Somers Ltd., Birmingham, England. He had been development engineer with Carrier Corp., Syracuse, N. Y.

DONALD E. FLINN is now sales manager at Aero Engineering Co., a division of the Garrett Corp. He had been a district manager at Aero Engineering.

LOUIS C. FRANK has been made chief engineer at the Aurora Plant of Caterpillar Tractor Co. He had been chief engineer of Trackson Co. in Milwaukee, a subsidiary of Caterpillar, since 1951. He joined Trackson in 1929.

MARTIN J. LEFF is now a development engineer, gasturbine department, Lycoming Division, Avco Mfg. Corp. He was micro wave technician, U. S. Army Signal Corp., Fort Monmouth, N. J.

WILLIAM FISCHER is now senior mechanical engineer with Rabinow Engineering Co., Washington, D. C. He had been senior mechanical engineer with Telautograph Corp. in New York City.

Obituaries

CARL HINSHAW

Carl Hinshaw, a member of the House of Representatives since 1938, died August 5. He represented the 20th District of California, which includes the Pasadena-Glendale area near Los Angeles.

Hinshaw was a member of the House Interstate and Foreign Commerce Committee, and the Joint Congressional Committee on Atomic Energy. A member of SAE since 1945, he served as a session chairman at the 1955 SAE National Aeronautic Meeting. At the 1954 Aeronautic Meeting, he spoke on atomic energy.

Hinshaw was born in Chicago in 1894. He attended Valparaiso University in Indiana, and Princeton University, where he received a civil engineering degree in 1916. He took postgraduate work at the University of Michigan in business administration, 1916–1917, then enlisted in the Army.

While in the service, he attained the rank of captain in the Engineers Corps. Returning to Chicago, he entered the automobile business, later shifted to investment banking. In 1929 he moved to Pasadena and began a real estate and insurance business.

In 1948 he was awarded the citation of honor by the Air Force Association, and in 1953 he received the Wright Brothers Memorial Trophy of the National Aeronautic Association. He was adviser to the Radio Technical Commission for Aeronautics and president of the Aero Club of Southern California in 1953–1954. He was also an Associate Member of the American Society of Civil Engineers.

CLAUDE EVELYN WRIGHT

Claude Evelyn Wright, president, Maitland Charts Ltd. died March 25. He had been a member of SAE since 1938. He was also an Associate Member of American Institute of Electrical Engineers.

Wright received a B. S. degree in electrical engineering from the University of New Zealand in 1925. After graduation he joined General Electric Co. in the engineering department. Two years later he was made superintendent in charge of the factory manufacturing shovels for Jones Shovel Co. Ltd.

From 1929 to 1933 Wright was with Ontario Steel Products Co. Ltd. He left Ontario Steel to form a partnership in Maitland Charts Ltd. In 1937 he returned to Ontario Steel as chief engineer in charge of production. During World War II Wright was with the Department of Munitions and Supply, first in joint charge, and later as director of gun production.

In 1946 Wright returned to Maitland Charts as president, a position he held until his death.

WILLIAM H. NAEGELY

William H. Naegely, director of laboratories at J. I. Case Co., died April 1.

Naegely attended Penn State College, majoring in metallurgy, and was graduated from the University of Michigan with a B. S. degree in chemical engineering in 1920. He then joined Ingersol Rand Co. as assistant metallurgist. The following year he was made special assistant to the president of Elk Tanning Co. From 1922 to 1925 he was head chemist at Chevrolet Motor Co.

He joined J. I. Case in 1925 as chief metallurgist. In 1949 he was made director of laboratories.

Naegely became a member of SAE in 1944. He was also a member of American Foundrymen's Association, American Society for Testing Materials, and the American Society for Metals.

WILLIAM G. STERNBERG, JR.

William G. Sternberg, Jr., retired president of Sterling Division, White Motor Truck Co., died March 16. He was 70 years old.

Sternberg began his industrial career with Sterling Motor Truck Co. in 1904 as a mechanic. He was advanced to foreman, and then superintendent. In 1922 he was made factory manager. Two years later he was named president of the company. In 1952, when White Motor Truck Co. acquired Sterling Truck Co., Sternberg was made president of the Sterling Division. This position he held until his retirement in 1955. Sternberg was a member of SAE for the last 31 years.

VICTOR A. WEGNER

Victor A. Wegner, zone manager, Sun Electric Corp., Atlanta, Ga., died May 3. He had just recently joined the corporation.

Wegner attended the University of Wisconsin, receiving a BS in Chemistry in 1929. Immediately upon graduating, he joined Flintkote Co., Atlanta, as a chemical engineer. In 1933 he moved to Gulf Oil Corp. as an automotive sales engineer. He held that position until 1956, when he joined Sun Electric Corp.

H. B. MILLER

H. B. Miller, supervisor, technical service department, Marketing Division, Ohio Oil Co., died May 24.

Miller began working in the automotive field in 1912 as an apprentice machinist for Toledo Bridge & Crane Co. In 1915 he joined Willys Overland Co. as a tool and die maker. During World War I he was a machinist in the United States Navy. From 1919 to 1927 he was co-owner in the Toledo Cylinder Regrinding Co.

He became a partner in the D & M Rubber Co. in 1927. Miller joined the Ohio Oil Co. in 1933 as automotive engineer. He was made fleet sales engineer in 1946, and in 1955 he was promoted to supervisor of the technical service department. He had been a member of SAE since 1944.

WILLIAM A. PREISH

Lieutenant William A. Preish died January 18 at Lackland Air Force Base, San Antonio, Texas.

Preish received his B. S. degree in mechanical engineering from Michigan State College in 1954. He had been an SAE student branch member while at college.

Before joining the Air Force, he was an engineer in training at the Central Foundry Division, General Motors Corp.

WHAT GOES ON

in SAE nationally . . .

SAE's Golden-Anniversary-Year president gives his up-to-the-minute answer in this brief article.

C. G. A. Rosen,
SAE President in 1955

Excerpts from talk given at SAE Northern California Section, May 23, 1956.

WHAT is SAE planning for the benefit of its membership in its future outlook and scope?

Last year (1955) was our Golden Anniversary year. It permitted a critical study of the past, in retrospect. It gave opportunity to evaluate the errors committed; and underscored the advantages and gains achieved. These evaluations provided the stepping stones to bridge the gap to the future and gave impetus to clarify that future . . . all this for the purpose of preparing the way for our future generation of engineers.

To achieve these ends there was need for careful study of the concept of SAE's corporate structure; a need to keep it flexible; to live with the advancing pace of technology; to overcome any resistance to need for change. This encouraged the overhaul of policies; the setting up of guideposts for Sections, Divisions, and Groups; the crystallization of a philosophy for serving member needs geographically, technically, and socially. It also called for a new format for an equitable system of granting honors and awards.

These analyses soon emphasized the evaluation of the physical service facilities. It indicated the need for improved facilities at new central headquarters in New York. Even though the membership growth has been tremendous, the Headquarters Staff increase has been at a minimum. The effectiveness of the Staff has, therefore, been exceptional in accommodating the expansion of a system of activities and keeping pace with modern technological advances.

The philosophy has been expressed that SAE cannot have "cast iron pigeon holes" to classify the new age of technical service, but must have "rubber expediting channels," flexible to changing needs in order to set up, progressively, any new or changing activity in response to anticipated needs. The future needs of SAE membership emphasized fluidity in our organization in order to cope with demands. This has led to the setting up, by President Delaney, of a committee group headed by SAE Past-President R. J. S. Pigott, charged with the challenge of finding solutions to problems which will beset us by our future expanding technology.

New Areas for SAE

Solutions to these challenges are required in knowledge of facts, in the ability to disperse information, and in the necessity for establishing standards and nomenclature.

As an example, let us consider the gas turbine.

We are told, in some quarters, that sport cars will be equipped with gas turbines within five years, that military equipment may well be propelled by gas turbines in a few years. For SAE this involves our activities in new approaches which must give consideration to heat transfer, regenerators, special materials, composition of fuels, the requirements of servicing. The automotive gas turbine could revolutionize the service station. The ability of the gas turbine to digest multi-fuels requires a knowledge of the limitations of petroleum properties to achieve livable maintenance values.

The use of coal as gas turbine fuel is an economic necessity for

MATERIALS ACTIVITY . . .

. . . will continue to serve automotive engineers; welcomes suggestions for papers.

THE prime function of the Engineering Materials Activity is to help automotive engineers with their particular materials problems. This basic philosophy on which the Engineering Materials Activity was founded was reaffirmed during a recent meeting of the Activity Committee in Detroit. Papers sponsored by the Activity will continue to be slanted toward automotive engineers and not to materials men per se.

Vice-Chairman for meetings Muir Frey pointed out that for the Activity to be of utmost service to other Activities, it must keep informed on what technical problems are most pressing in each field.

The Engineering Materials Activity will continue to present papers at invitation of other Activities at meetings and locations where the other Activities desire, and whenever possible, on subjects requested by these Activities.

Currently this Activity is scheduled to sponsor technical sessions at the 1956 National Tractor Meeting in Milwaukee, Sept. 10–13; the 1957 Annual Meeting, Detroit, Jan. 14–18; the 1957 Passenger Car, Body, and Materials Meeting, Detroit, March 5–7; the 1957 Production Meeting, Buffalo, March 20–22; the 1957 Aeronautic Meeting, New York, April 2–5; the 1957 Summer Meeting, Atlantic City, June 2–7. In addition, the Engineering Materials Activity will welcome invitations to present papers at the other 1957 National Meetings.

SAE NATIONAL TRANSPORTATION MEETING

Hotel New Yorker, New York, N. Y.

October 10-12, 1956

General Chairman: **M. C. HORINE**, Consulting Engineer, Mack Trucks, Inc.

Wednesday, Oct. 10

Subjects covered: **Stopping Ability of Motor Vehicles Selected from the General Traffic; Bus Requirements; Electrical Trends in Motor Trucks; and Electrical Equipment—Heavy Duty Progress.**

Thursday, Oct. 11

Papers entitled: **A Resumé of Bus Suspensions; and The Engineer in Fleet Maintenance.**
Luncheon, 12:00 noon: **with talk by Amos E. Neyhart, Pennsylvania State University, entitled "Mechanic Education and Training"**

Friday, Oct. 12

2 Symposiums: **Design for Maintenance; and Unusual Vehicles Operating in Alaska.**
Motion Pictures: **30-minute color films illustrating Alaskan operations**

Special Event:

Wednesday afternoon: **Trip to General Motors Training Center,** Union, N. J.

SAE National Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display

Hotel Statler **Los Angeles, Calif.** **October 2-6, 1956**

Aircraft Production Forum October 2-3

Sponsor: **L. A. CARTER**, Douglas Aircraft Co., Inc.

Gen. Chr.: **H. V. SCHWALENBERG**, North American Aviation, Inc.

Eight all-day panels and six half-day panels relating directly to the Forum's theme—"Manufacturing and Engineering Discuss Production Problems of Tomorrow's Flight." Panel members have been selected from the organizations of the customers, prime contractors, major subcontractors, and suppliers.

Aeronautic Meeting October 4-5

Gen. Chr.: **F. H. SHARP**, Convair Division, General Dynamics Corp.

One panel discussion: "Icing"—presenting material on improved icing simulation methods, problems of icing simulation, and development of new icing facilities.

Ten technical sessions, morning and afternoon, at which 24 papers of importance in the aeronautic field will be presented.

One evening session previewing a Walt Disney motion picture showing the historical background and peacetime application of nuclear energy.

Aircraft Engineering Display October 2-5

Chr.: **J. H. KINDELBERGER**, North American Aviation Corp.

85 Up-to-the-Minute Aeronautical Developments

the railroads of tomorrow. Another development which anticipates a rather broad fuel appetite is the free piston gas turbine combination. Because of lower turbine gas temperatures it provides the opportunity for utilizing steam turbine materials. It also yields performance characteristics similar to those found in hydraulic transmissions.

Nuclear Power Studied

Nuclear power is well within the scope of our study. No one knows when certain breakthroughs may be of significance in utilizing nuclear power in broader fields of application. The first atomic submarine had available a maximum steam temperature of 600 F, the second unit has 2000 F. Who knows the end of the lane of this fabulous source of power? An SAE committee involving the top nuclear scientists in the automotive industry has been set up to study the advancing progress and to feed into the SAE bloodstream, information and guidance on nuclear power and the application of radio-isotopes to industrial pursuits.

More New Horizons

The guided missile projects and similar ventures into new horizons of technological development are well within the province of SAE to evaluate. The subject of automation is paramount in the minds of our production people. At the 1956 Production Meeting in Cleveland, a most aggressive and progressive program was in evidence. This Activity has founded the "Forum" idea and its influence is growing by leaps and bounds into other activities of our Society. Automation has introduced a new era of cooperation of engineering and manufacturing personnel which has stimulated the need for anticipating future tooling changes and design modifications as occasioned by customer demands. These influences affect investments frozen into multi-million dollar production lines.

The Manhattan project has taught industry a new lesson. The ancient, but not too far-removed program of trial and error testing, gave way in the Manhattan project to the necessity for research and manufacturing to begin at the same starting point and to follow parallel lines of progress until the ultimate product was achieved. Manufacturing and engineering are closer partners because of the introduction of the computer. The computer has reduced the number of possible variables and eliminated the necessity for tedious and time-consuming methods for cancelling arbitrary guesses.

SAE—Pipeline of Knowledge

SAE is setting up a pipeline of knowledge to compass the entire technological world. Technology has brought our present world together as never before. We are a "one world" people speaking the same technical language. This should initiate a world movement in the exchange of ideas. Methods to achieve rapid transit and rapid communication are constantly our goal. To acquire the advantages of foreign thinking in our own circles, SAE is setting up avenues for the exchange of technical information. We hope to expand the Forum idea to visitations by foreign engineers.

In our growing, changing world of technology, SAE hopes to keep its virile activities matched to the pace of progress. In scientific development it plans to envision distant horizons by utilizing the dedicated leadership of American automotive engineering. With these essentials, we may expect a glorious future. Who will dare set limits as to what may be reached beyond present horizons?

Rosen . . .

. . . to give Buckendale Lecture at Chicago on October 9.

THE 1955 L. Ray Buckendale lecture will be given by Dr. C. G. A. Rosen, consulting engineer to the president, Caterpillar Tractor Co., on October 9, at the Knickerbocker Hotel in Chicago. The SAE Chicago Section will act as host.

Originally scheduled for presentation last year, the lecture was postponed because of the illness of Dr. Rosen.

As L. Ray Buckendale was particularly interested in developing the latent abilities of young engineers, the program is to be directed especially toward student and junior engineers.

Dr. Rosen's talk will cover "The Role of the Turbine in Future Vehicle Powerplants," a topic that should prove of particular interest to young engineers—"the engineers of the future"—who will find in this lecture up-to-date turbine information not generally available in textbooks.

Production . . .

. . . papers will help small manufacturers.

IN the future more technical papers sponsored by the Production Activity will emphasize the production problems of the small and medium-sized manufacturer, it was decided at a recent meeting of the Production Activity Committee. Particularly in automotive areas of the country such as Buffalo, in which small and medium-sized companies predominate, papers will be slanted to solve their unique manufacturing problems.

It was felt that, in general, the small manufacturer is particularly interested in new processes and methods since they offer him greater opportunity to compete with large, fully-automated manufacturers.

A processing innovation for producing more efficiently and economically can make a completely automated line obsolete. The small, non-automated manufacturer can switch to new methods much more readily than the larger who has millions of dollars tied up in automated lines.

SAE National Meetings

1956

September 10-13
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 2-6
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 10-12
Transportation Meeting
Hotel New Yorker
New York, N. Y.

November 1-2
Diesel Engine Meeting
The Drake, Chicago, Ill.

November 8-9
Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

1957

January 14-18
Annual Meeting and
Engineering Display
The Sheraton-Cadillac
and Statler Hotels
Detroit, Mich.

March 5-7
Passenger Car, Body, and
Materials Meeting
The Sheraton-Cadillac
Detroit, Mich.

March 20-22
Production Meeting and
Forum
Hotel Statler, Buffalo, N. Y.

April 2-5
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering Display
Hotel Commodore, New York, N. Y.

June 2-7
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 12-14
West Coast Meeting
Olympic Hotel, Seattle, Wash.

September 9-12
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

CRC Reports on Tests for Airframe Lubes

CONSIDERABLE progress has been made in developing test techniques for predicting how airframe lubricants will perform in service, according to a CRC report (CRC-284), "Interim Progress Report on Airframe Lubricants."

The report covers the first four years of activity of the Group on Airframe Lubricants of the Coordinating Lubricant & Equipment Research Committee, which was organized to carry out this project. The work is being done at the request of the military services.

Progress is reported on the development of test techniques for measuring the following properties of airframe lubricants:

1. High-temperature performance of greases for antifriction bearings.
2. Fretting corrosion.
3. Rust - preventive properties of greases.
4. Performance of greases in plain bearings.
5. Performance of greases in screw thread and gear mechanisms.
6. Storage stability of greases.

In each case, a brief background is given and progress to date, together with a discussion of areas where more work is needed

The report also gives in detail tentative drafts for the following research techniques:

1. Determining Performance Characteristics of Lubricating Greases in Antifriction Bearings at Elevated Temperatures (CRC Designation L-35).
2. Measuring the Effect of Lubricating Grease Characteristics on the Minimizing of Fretting Corrosion on Unshielded Thrust-Loaded Ball Bearings (CRC Designation L-36).
3. Determining Corrosion on Grease-Coated Ball Bearings (CRC Designation L-34).

CRC Studies Hot-Fuel Properties

A SIMPLE method of predicting tank pressures resulting from hot fuel is presented in a CRC report (CRC-286), "Volatility Characteristics of Aircraft Fuels at Elevated Temperatures."

This information is needed because at high speeds, aerodynamic heating raises temperatures to the point where some fuels develop excessive vapor pressure inside the fuel tank. For example, at 450 F, JP-4 fuel will exert a vapor pressure inside the tank of 200 psia. A heavier fuel, such as No. 2 furnace oil, on the other hand, will exert a pressure of only 17 psia at the same temperature.

Laboratory tests were made in a simulated tank, of eight hydrocarbon fuels, covering a wide range of volatility and representing both fuels now in use in aircraft and extending to heavy diesel fuel. From these data, a "volatility factor" was evolved, which is used in calculating the vapor pressure and other properties of a fuel at any temperature.

The text of the report also contains data on specific gravity and the molecular weight and viscosity of fuel vapors.

In addition, the volume contains the complete test reports of the three companies participating in this phase of the work. They cover:

1. "Volatility Characteristics of Eight Types of Turbine Fuel at Temperatures to 450 F."
2. "Volumetric Behavior of a Turbine Fuel Oil."
3. "Phase Behavior of a Modified Turbine Fuel."

Also included are the detailed vapor pressure calculations of two petroleum companies. These calculations were made to find out if the calculation techniques based on the physical fuel properties could accurately predict fuel vapor pressures at high temperatures. The agreement between the calculated results and the test results was good.

CRC-286 contains 181 pp, including tables, charts, and graphs. It is available from SAE Special Publications Department. Price: $5 to members, $10 to nonmembers.

CRC Reports on Maximum ON Requirements

THE final year of a four-year cooperative program for investigating the octane-number requirements of passenger cars is covered in a CRC report (CRC-287), "Octane-Number Requirement Survey—1954."

The 1954 program included a statistical survey of 1950–1954 model cars and a survey of the requirements of nine 1954 makes having engines and transmissions of new design.

Requirements at selected engine speeds were obtained on an optional basis and thus were determined for only a limited number of cars. The 1954 survey, therefore, deals entirely with maximum octane-number requirements.

Twenty-six laboratories submitted data on 512 cars of 18 makes. Of these, 223 were 1954 models of nine makes tested because of special interest in new-design engines or transmissions. The balance were tested to determine the distribution of octane-number requirements of 1950–1954 model cars weighted according to national registration figures.

Here are the findings of the report, in brief:

1. Maximum octane-number requirements (expressed as the Research and Motor method octane numbers of the reference fuels giving borderline noise —defined as combustion noise due to spark knock or surface ignition, whichever was limiting) are summarized in Table 1.

2. The maximum requirement in terms of primary reference fuels to satisfy 50% of the 1950–1954 models was about 2.5 octane numbers higher than the requirement of the 1946–1951 models as determined in the 1951 statistical survey. A similar increase in requirement was found using full-boiling-range reference fuels.

3. The primary reference fuel requirement at the 50% satisfied point for the 1950–1951 models tested in the 1954 survey was about 2.5 octane numbers higher than the requirement for a similar group of 1950–1951 models tested in 1951.

4. Data were available from the 1953 survey for four of the nine makes designated as new design in 1954. Requirements with primary reference fuels for the 1954 models of make G were 3–4 octane numbers lower than for the 1953 models. For makes S, L-2, and K the requirements for the 1954 models did not differ significantly from the requirements of the 1953 models.

5. The owners reported data on the tank fuel in 285 of the 305 cars in the statistical survey. Of these 285 cars 27% of the owners reported combustion noise with the tank fuel while 33% of the cars were found to give noise by the test observers. In the new-design cars the corresponding percentages were 14 and 18%, respectively.

6. The percentages of cars reported to be spark-knock and surface-ignition limited are given in Table 2.

7. Of all the cars for which owner reports were available 17% of the cars tested by the observers in the East gave noise on the tank fuel. The owners reported noise in 10% of the cars. In the Central and West Coast areas the corresponding figures were 34% and 29%.

8. Despite the fact that the average Research method ratings of the premium- and regular-grade tank fuels found in the Eastern area cars were appreciably higher than for the Central-West Coast area cars, no differences in requirement distribution between cars in the two areas were found in the statistical survey.

9. The Research and Motors method ratings of the tank or optional fuels giving borderline noise in 91 cars were compared with the maximum requirements of these same cars measured with full-boiling-range reference fuels. Requirements measured with full-boiling reference fuels approximated those assigned with the commercial gasolines.

10. The average hill correction, defined as the difference between the maximum octane-number requirements measured under hill and level-road conditions, were 2.2 using primary and 1.9 using full-boiling-range reference fuels. These corrections are about the

Table 1—Maximum Octane-Number Requirements

Make	No. Tested	Octane Number for Indicated % Satisfied			
		50%		90%	
		PR[a]	CR[b]	PR[a]	CR[b]
		Statistical Survey 1950–1954 Models			
All	305 Research	85.0	86.5	90.5	92.0
	Motor	85.0	80.0	90.5	83.5
		New-Design Cars 1954 Models			
S	22 Research	91.0	92.0	94.0	94.0
	Motor	91.0	83.5	94.0	84.5
L-2	25 Research	90.0	91.5	92.5	93.5
	Motor	90.0	83.0	92.5	84.0
G	25 Research	87.5	89.0	90.5	91.0
	Motor	87.5	81.5	90.5	82.5
L-3	22 Research	87.0	87.5	90.0	91.5
	Motor	87.0	80.5	90.0	83.0
M	26 Research	85.5	87.0	88.0	89.5
	Motor	85.5	80.5	88.0	82.0
O-M	25 Research	85.5	86.5	90.0	91.5
	Motor	85.5	80.0	90.0	83.0
Q-A	25 Research	84.5	85.5	88.0	89.0
	Motor	84.5	79.5	88.0	81.5
K	24 Research	83.5	84.5	89.5	92.0
	Motor	83.5	78.5	89.5	83.5
D	29 Research	83.5	84.5	87.0	88.0
	Motor	83.5	78.5	87.0	81.0

[a] PR = Primary reference fuels.
[b] CR = Full-boiling-range reference fuels.

Table 2—Percentages of Cars Spark-Knock and Surface-Ignition Limited

	Reference Fuel Type		
Statistical Survey	Primary	Full-Boiling	Tank Fuel[a]
% Spark-Knock Limited	94	91	87
% Surface-Ignition Limited	6	9	13
New-Design Cars			
% Spark-Knock Limited	96	93	91
% Surface-Ignition Limited	4	7	9

[a] Includes only those cars giving noise on the tank fuel.

Technishorts . . .

HYDRAULIC HOSES—Minimum burst pressure of SAE 100R1 and 1002R hoses in the ¼ to ½ in. sizes has been increased to bring allowable pressure to values proved in service. Values for SAE 100R1 have been increased 1000 psi, so that they are 11,000 psi for the ¼ in. ID hose, 9000 psi for the ⅜ in. ID hose, and 8000 psi for the ½ in. ID hose. Values for the SAE 100R2 hose have been increased 2000 psi, so that they are 20,000 psi for the ¼ in. ID hose, 16,000 psi for the ⅜ in. ID hose, and 14,000 psi for the ½ in. ID hose.

CARBURETOR FLANGES—To the SAE Standard on Automotive Carburetor Flanges has been added (1) a new type of air horn flange utilizing a center stud air cleaner attachment and (2) dimensions for four barrel carburetors. These revisions bring the standard in line with present practice.

SHEET STEEL TERMS—The following nomenclature has been standardized for designating sheet steel surface qualities:

"E" for Exposed Parts. For steel with the greatest usage and the better finish. Exterior finish of exposed parts is more critical than that of unexposed parts.

"U" for Unexposed Parts. For steel with interior finish where defects are permitted that cannot be tolerated in "E" steels.

The need for this nomenclature grew out of a confusion that existed with regard to cold rolled sheet steel. The confusion was brought about because two of the largest users employed the same letter symbols, but to denote exactly opposite meanings in identifying body part requirements. The newly standardized symbols were found to be agreeable to both steel users and producers before being proposed to the SAE Iron and Steel Technical Committee.

same as those observed in the 1953 survey.

11. The percentage of the new-design model cars which gave maximum knock at part throttle varied from 5% for make L-3 to 73% for make S.

CRC-287 contains 91 pp., including graphs, charts, and tables. It is available from SAE Special Publications Department. Price: $4 to members, $8 to nonmembers.

CRC Releases Ten New Reports

The following Coordinating Research Council reports have been released for distribution and are available from SAE Special Publications Department.

(This is a complete list of CRC reports released since publication of the listing of CRC reports on page 96 of the March, 1955 SAE Journal.)

Aviation Fuels

Detonation-Laboratory

CRC-282—Investigation of Motor Grade Fuel as a Potential Fuel for Light Aircraft (10/53, revised 1/55). Priced at $1.00 to SAE members; $2.00 to nonmembers.

Volatility

CRC-286—Volatility Characteristics of Aircraft Fuels at Elevated Temperatures. Priced at $5.00 to SAE members; $10.00 to nonmembers.

Diesel Fuels

CRC-288—A Survey of Available Information on the Deposit-Forming Characteristics of Diesel Fuels and Engines, March 1955. Priced at $5.00 to SAE members; $10.00 to nonmembers.

CRC-291—Significance of the Cetane Number of Diesel Fuels (8/55). Priced at 50¢ to SAE members; $1.00 to nonmembers.

CRC-292—Report on Fuel-Scale Field Service Tests of Railroad Diesel Fuels (11/55). Priced at $5.00 to SAE members; $10.00 to nonmembers.

Motor Fuels

Detonation Full-Scale

CRC-287—Octane Number Requirement Survey (1954). Priced at $4.00 to SAE members; $8.00 to nonmembers.

Detonation

CRC-293—Correlation of Road Antiknock Ratings in Octane Number Requirement Survey Cars in Test Cars—Part II, September 1955. Priced at $1.00 to SAE members; $2.00 to nonmembers.

Volatility

CRC-283—Effect of Fuel Volatility on Crankcase Oil Dilution (2/54). Priced at $1.00 to SAE members; $2.00 to nonmembers.

CRC-289—Passenger Car Hot Weather Fuel Handling Difficulties, Indio, California, 1953. (12/55). Priced at $5.00 to SAE members; $10.00 to nonmembers.

Lubricants

CRC-284—Interim Progress Report on Airframe Lubricants (6/54). (Copies no longer available.)

Fuel Volatility Affects Crankcase Oil Dilution

CRANKCASE oil dilution increases as the fuel 90% point is raised, according to a CRC report (CRC-283) entitled "Effect of Fuel Volatility on Crankcase Oil Dilution." The report points out, further, that the magnitudes of the dilution obtained by the five participating laboratories appear to vary somewhat for corresponding 90% points.

None of the laboratories reported mechanical difficulties with the higher boiling fuels, although poor warmup was observed with the heavier gasolines.

The report states that the data obtained are in general agreement with earlier work on the effect of fuel volatility on crankcase oil dilution reported in the CRC Handbook, 1946, p. 134. It also agrees with the earlier work carried out by the Bureau of Standards for the Cooperative Fuels Research Steering Committee.

Because of the lack of data on the effect of engine make, the report does not give any conclusions on the effect of engine make on the dilution.

The 23-p. report gives the data developed by each of the five laboratories, as well as a summary of results. It also contains the "Method of Test for Dilution of Crankcase Oils by Partial Pressure Distillation" and excerpts from the CRC Report "Review of Existing Pertinent Data on the Influence of Upper Boiling Range on the Performance of Motor Fuels."

CRC-283 is available from SAE Special Publications Department. Price: $1 to members, $2 to nonmembers.

ENGINEERS

. . . Electrical
. . . Mechanical

CHALLENGING OPPORTUNITIES
To men with a degree and
an interest in

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and TEST

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You will constantly be doing development work and testing in one of the most versatile Laboratories in the country . . . working with the top men in the field and with the finest test, research and development facilities. We are in the process of a Major, Permanent, Expansion Program. New plant facilities being added in suburban Milwaukee area.

To aid you in your professional advancement AC will provide financial assistance toward your Master's degree. A Graduate Program is available evenings at the University of Wisconsin, Milwaukee.

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General Motors Corp.
Milwaukee 2, Wis.

Dynamic Threat Creates Defense Race

Based on paper by

MAJOR-GEN. FREDERIC H. SMITH, JR.
Continental Air Defense Command

THERE are three essentials to an overall continental defense system to make it effective.

The first of these is an early warning system to announce the approach of enemy aircraft. We must know as soon as possible after take-off that bombers are en route toward this continent.

The second requirement is a surveillance capable of detecting and following with accuracy all approaching bombers. Since this must extend as far from our shores as possible, there is needed a combination of radars, fighter-interceptors, and long-range interceptor missiles on the weapons side.

The third need is local defense at our most vital targets. This calls for the deployment of a large number of short-range missile batteries to attack those bombers getting through the area weapon defense. (Paper "Your Air Defense" was presented at SAE Southern California Section Meeting, May 9, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

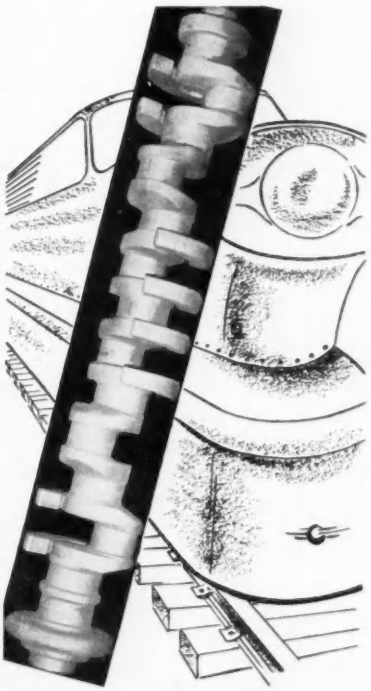
Problems of Using Torque Converters in Excavators

Based on paper by

P. J. SWANSON and J. H. MEIER
Bucyrus-Erie Co.

THERE are many types of torque converters as well as engines, flywheels, governors, and clutches offered for excavator service. The best transient performance is obtained by selecting components which will keep power losses following rapid acceleration of load to a minimum. These losses are caused by the energy required for engine acceleration and by lower torque-converter efficiency during transient periods.

The use of torque converters in excavating machinery presents certain problems which differ from those usually encountered in other industrial applications in that the load imposed by an excavator on its powerplant varies rapidly over a wide range. For instance, when digging blasted rock, load increases sharply when the dipper meets a large boulder, and then de-



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Park Drop Forge is proud that Park "Die-Forged" Crankshafts are specified for the diesel engines that power these trains of tomorrow.

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How many jobs can a vibration exciter do?

SHAKER SYSTEMS can help you in *at least* five important ways.

Fatigue testing. Shakers have both the range and capacity to determine fatigue limits of structural members, assemblies, aircraft wing and tail structures. Peak forces of up to 25,000 pounds are now obtainable with MB Exciter Systems.

Environmental vibration testing to MIL-E-5272 and other government specifications. This is most important now for assuring reliability of performance in military production. But the same techniques can be used also to improve *all* types of products.

Noise. Just where in a product does it come from and how to eliminate it? An MB shaker helps pinpoint the disturbance by letting you vibrate the product through a whole range of frequencies with the twist of a dial.

Complex wave testing, including random motions. This is something *new!* It subjects a specimen to the same kind of vibration as that encountered in actual service. MB electrodynamic shaker systems offer the frequency range, high acceleration, and freedom from distortion needed for this kind of job.

Production and Quality Control. *Your* ideas are needed here. For example: Someone discovered that size of fine powder particles which sift readily through a screen varies with the screen's frequency of vibration. Permitting easy control of frequency, an MB shaker is capable of working on a *production* line! Tubes too are being production-tested with MB Exciters.

If you need help in putting vibration exciters to work, get in touch with MB . . . leading producer of vibration test equipment.

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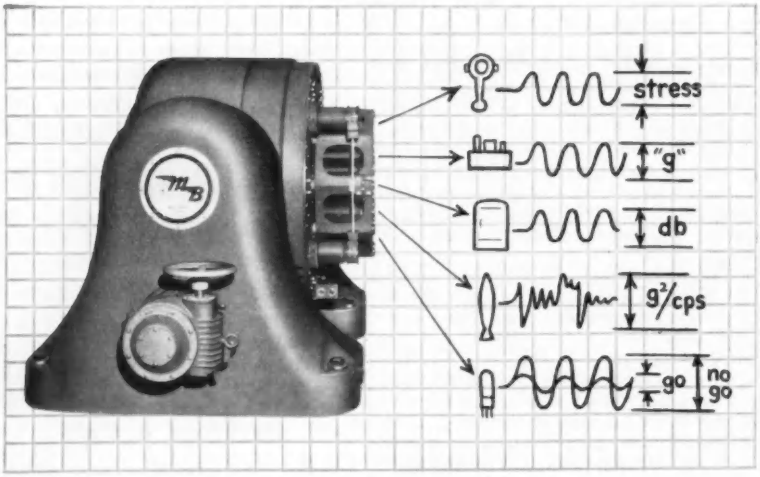

creases to near zero if the dipper slides over it or the boulder breaks loose.

It's highly desirable to have maximum power while the excavator digs in the bank. Most other operations require less than full power. Power may be lost from any of the following factors:

1. Decrease in engine efficiency during periods of deceleration.
2. Slow governor action.
3. Decrease in torque converter efficiency due to changes in loads and speeds.
4. Power from burning fuel going into engine acceleration during transient periods.

Performance is also affected by the inertia of the rotating masses on both sides of the converter.

The Bucyrus-Erie Co. conducted tests in the field of an excavator equipped with a torque converter. The performance of the engine during transient loads was observed under various conditions. This information, plus the effect of an engine governor, the internal losses in the torque converter during changes in loads, and the effect of flywheel inertia on transient performance is recorded in the paper "Effect of Rapid Load Changes on Torque Converter Performance," which was presented at SAE Golden Anniversary Tractor Meeting, Milwaukee, Sept. 13, 1955. Complete paper is available from SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers.

Multigrade Oils Help Reduce Deposits, Knock

Excerpts from paper by

JOHN G. MOXEY, JR.
Sun Oil Co.

WE have recently seen a general increase in horsepower, compression ratio, and octane requirement in passenger cars. These cars are much more sensitive to combustion-chamber deposits, knocking, and preignition. Since lubricating oil deposits are an important factor in these respects, it is desirable to do everything possible to reduce the deposit-producing tendency of motor oils. Multigrade oils are a very successful solution to this problem. The use of these oils reduces the ultimate octane requirement increase by several numbers. As would be expected, the greatest benefit is obtained when using multigrade oils in an engine from the beginning. Prevention of combustion-chamber deposits extends the period of new car power and pep.

Modern driving habits in the United States are not particularly favorable to optimum engine conditions. About

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38% of all trips are less than 3 miles one way. Over 62% of all trips are less than 13 miles one way. Much of this is under traffic or suburban driving conditions. This type of driving is conducive to building up combustion-chamber deposits. The reduced tendency toward deposits by multigrade oils is thus quite important in high compression engines.

The average trip mileages given above have other important effects. Depending on the weather, it requires 6–12 miles of driving to warm up an engine fully. This is entirely aside from the fact that the temperature gage will show normal coolant temperature in a relatively short time. When not fully warmed up, an engine is subject to condensation of water and fuel combustion acids. These contribute markedly to rust, wear, and harmful deposits. These problems are not solved by multigrading. A reliable multigrade oil must gain protection by the use of additives similar to any other top-quality motor oil. It may have special additives to combat deposits, neutralize acids, prevent rust, and keep wear at a minimum. In the latter case, the higher valve spring pressures and loads in newer engines have posed an entirely new wear problem. Multigrade oils may also contain an additive effective in preventing excessive valve lifter and cam wear.

The use of multigrade oils of good quality provides benefits which are readily apparent to the driver. Ease of starting is particularly evident. Engine freedom and improved pep during warm up are easy to observe. A later benefit, but one which is quite noticeable, is the reduction in knocking tendency of the engine. All of these increase the owner's satisfaction in his car. In many cases, the use of multigrade oils can be even more important. Some cars, because of individual characteristics, design, or use, cannot have freedom from combustion knock except by the use of oils which produce a very minimum of combustion-chamber deposits. An owner of such a car is very easy to convince that the additional expense is well worth while. (Paper "Multigrade Oils" was presented at a meeting of the SAE New England Section, Cambridge, Mass., Nov. 1, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

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Dry-Type Air Filter Has Many Applications

Based on paper by

HERBERT R. OTTO, JR.

and

JOHN C. COX

Purolator Products, Inc.

THE heart of the positive dry-type micronic air filter is the filter medium. This is a phenolic impregnated cellulose fibrous material. The porosity and resin impregnation can be controlled so that, although having a high degree of porosity, particles as small as one micron are filtered out.

In the positive dry-type filter the air passes directly through the filter medium to leave the particles of dirt behind. This is in contrast to the type which relies on baffles or other restrictions to cause the air to bounce around corners and drop dirt particles on the way.

Aside from automotive application, the positive type is being used on air compressors and promises to play a role in the field of ventilating and air conditioning. (Paper "Dirt Proofing Engines with Positive Air Filtration" was presented at SAE Metropolitan Section Meeting, New York, Dec. 14, 1955. It is available in full, in multilith form, from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Sealed Engine Just Around the Corner

Based on paper by

CARL T. DOMAN
Ford Motor Co.

THE charge has been made that modern vehicles are hard to service because engineers spend their time at the drawing board and in the dynamometer room and are rarely in the garage with a wrench in hand. The charge once had some foundation, but today the automotive engineer is much more appreciative of service problems.

In designing powerplants, the engineer is now striving toward a sealed unit which will require no serious mechanical attention over the life of the vehicle or until the engine should be replaced with a new one. Some of the major parts suppliers are predicting the advent of the sealed engine in a very few years and current models indicate we are well on our way toward this objective. (Paper "Service is Our Business" was presented at SAE Wichita Section Meeting, Nov. 18, and SAE Pittsburgh Section Meeting, Nov. 22, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Specialized or Basic Engineering Education

Based on papers by

T. L. PREBLE
Tide Water Associated Oil Co.

E. C. EASTON
Rutgers University

MURRAY SIMKINS
Commercial Car Journal

M. C. HORINE
Mack Mfg. Corp.

R. L. STANLEY
Diesel Engine Manufacturers Association

ENGINEERING school curricula can stand some modernizing according to representatives of industry at this symposium. They urged more specialized education so graduates can be immediately useful and productive. But educators responded with the contention that a basic engineering training is all that industry can properly expect in the limits of time normally available.

Transportation-minded industry representatives especially favored specialized training in colleges so engineer graduates can cope with practical problems after graduation. This, they think, can be achieved only by ruthlessly weeding out dead wood from the curriculum.

For example, surveying may afford excellent mental discipline as well as healthful outdoor exercise. But it may be omitted from a curriculum in favor of such things as nuclear phenomena which will help complete the automotive engineer's technical education.

The curriculum, it was suggested, should include chemical, electrical, metallurgical, hydraulic, and electronic courses—as well as the basic mechanical engineering. In certain areas of each of these specialized divisions, the transportation engineer requires knowledge beyond the usual scope to meet the special requirements for his own field.

For instance, he should understand the principles and practices of the mechanical engineering that go into the design and production of his vehicles. And he should be familiar with the chemical and thermodynamic phases of petroleum in so far as they affect

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the fuels and lubricants which he uses.

But technical competence is not enough. This specialized education must include technical know-how combined with an understanding of economics and management.

Educators, on the other hand, were a unit in feeling that basic engineering principles are most important to the engineer's development. Such an education, they pointed out, provides a sound basis on which industry can and does develop specialists through supplemental on-the-job training.

A college curriculum, the educators urged, must consist largely of basic principles. Material which is purely descriptive of current practice and which does not relate that practice to the underlying basic principles is not suitable.

Educational philosophy today demands an engineering curriculum which can produce a graduate capable of doing good engineering work throughout his lifetime. The goal of this engineering education is mastery of the fundamental scientific principles associated with any branch of engineering. The engineer's use of this knowledge is shaped by his company on the basis of its own experience and requirements. (Symposium "Education for Automotive Engineering" was presented at SAE Annual Meeting, Detroit, Jan. 10, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: $1.00 to members, $2.00 to nonmembers.)

Tests Throw Light On Dynamic Store Loads

Based on paper by

S. B. PFEIFFER
El Segundo Division, Douglas Aircraft Co., Inc.

LIGHT-WEIGHT stores are subject to higher acceleration than at present specified for determining the strength of airborne stores and suspension systems in landing conditions. While this discrepancy may not result in damage to the store suspension system, which may be critical for the heavier stores, it can result in service damage to the stores themselves or components carried therein. This fact is borne out by Douglas service experience.

The range of test data on dynamic store loads from landing is extremely limited and cannot outline a strength envelope for the many existing physical configurations.

Comparative tests show that the drop test provides a good example of some of the peak loads occurring during the life of the airplane. For a given contact velocity, airplanes in service equal or exceed the axial gear loads received in a drop test. Hence, the store loads obtained by these tests should be expected to be equal to, or less than, those which might occur in service.

A parametric study aimed directly at store loads from landing would provide extremely useful imformation by determining the relative importance of the various factors involved in dynamic store loads from landing. (Paper "Dynamic Landing Loads on Stores" was presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, October 13, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Turbojets Promise Reasonable Upkeep

Based on paper by

V. L. SCHATZ
A. L. WYNN
and
R. W. REMKE
General Electric Co.

ANALYSIS of military experience with turbojet engines for the purpose of deriving estimates of cost to support future engines of this type in commercial aircraft indicate the costs to be both reasonable and predictable.

When the reasons for sending engines to major overhaul are compared for three models (Fig. 1), foreign object damage is found to be the biggest single cause. On the face of it, the earliest model suffers the least, and the latest model the most, from this damage, but this cannot be interpreted

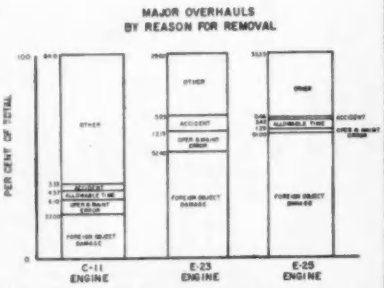

Fig. 1—Comparison of three turbojet engine models on the basis of reasons for sending them to major overhaul.

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Our engineers work on the very frontiers of present day scientific knowledge. We need your creative talents and offer you the opportunity to progress by making full use of your scientific ability. Positions are now open for aerodynamicists . . . mechanical engineers . . . mathematicians . . . specialists in engineering mechanics . . . electrical engineers . . . electronics engineers. For further information regarding opportunities in the Los Angeles, Phoenix and New York areas, write today, including a resumé of your education and experience. Address Mr. G. D. Bradley

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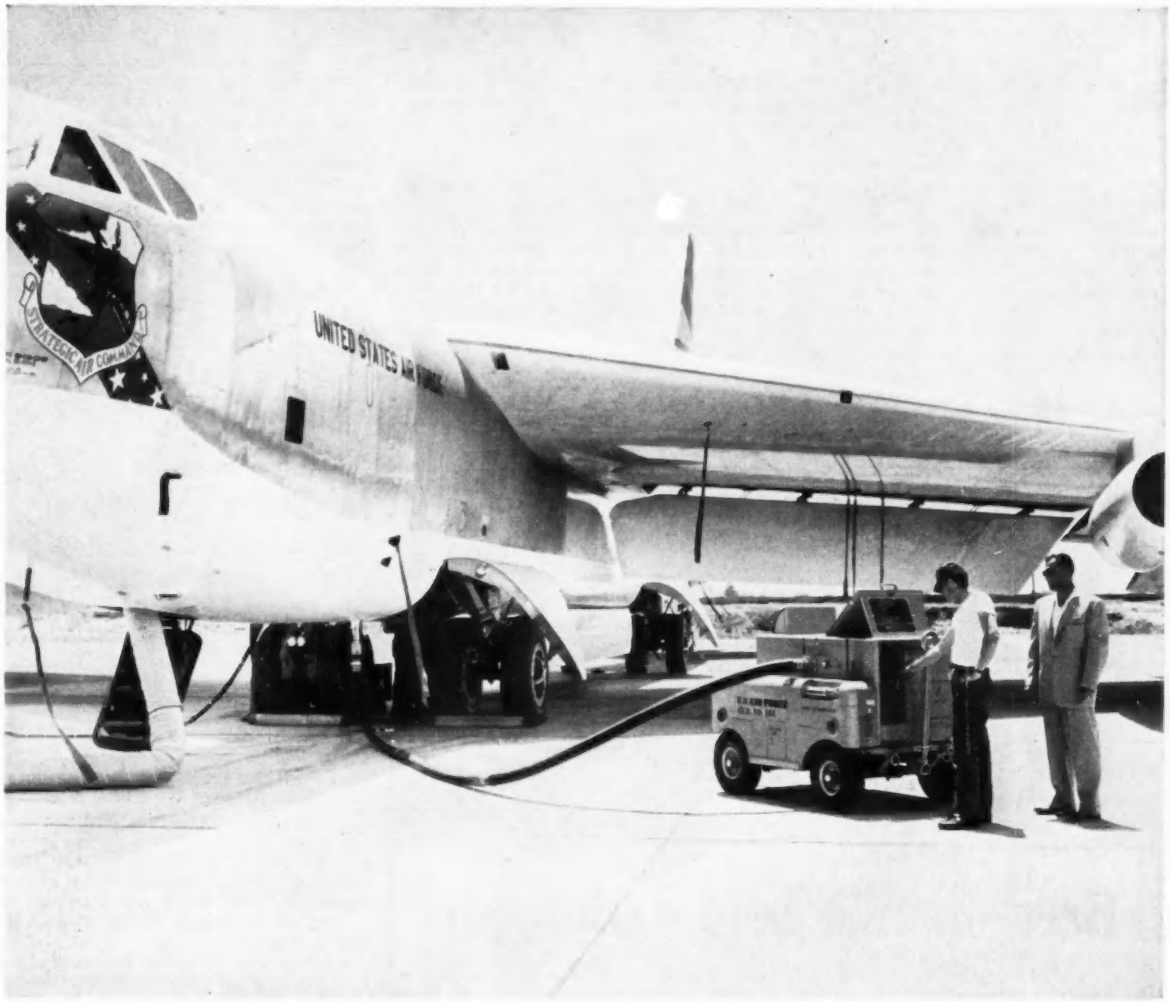

Mobile gas turbine power cart

takes only 30 seconds to start giant B-52 jet engines

The AiResearch MA-1A mobile gas turbine compressor, the first unit of its kind qualified by the Air Force to start the intercontinental B-52 bombers of the Strategic Air Command, is now in volume production at the AiResearch Manufacturing Division of Arizona.

Entirely self-contained, it furnishes a completely automatic source of compressed air power at the point of use. All components, parts and accessories are included in the fully-enclosed weather-proofed trailer.

The mobile unit weighs only 1150 pounds and may be controlled either from the instrument panel or from a remote control panel. It will start and maintain continuous operation at ambient temperatures ranging from −65°F to 130°F, together with the other extremes of environmental conditions encountered at airports throughout the world.

The two-stage gas turbine compressor may be removed easily from its trailer for use in other vehicles or as a stationary unit. It has an output capacity of 120 pounds per minute flow at 50 psia . . . enough power to meet all ground service needs for a modern airplane.

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as indicating an increasing incident rate. The comparison actually points out the effect of increased minor repair facilities.

The "-11" engine accumulated much of its experience when minor repair facilities for the J-47 were much less extensive than they are now. Many engines went to major overhaul for troubles other than foreign object damage which can now be corrected at the minor repair level. Since foreign object damage which can be corrected at minor repair level is still quite limited. these engines are going to major overhaul, thus explaining the higher percentages for the latest engines.

The analysis proves that care must be taken in using military experience as a basis for estimates because of the severe penalties imposed on engine and engine parts life. Aircraft are subjected to many touch-and-go landings during training; certain engine parts suffer thermal shocks during the shutdown and relight of practice air starts, while low engine utilization means more engines to support a given program with consequent difficulty in keeping engineering changes incorporated in the engine. (Paper "Jet Engines—What Price Power?" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

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10

Data Show Need For Better Lab Tests

Based on paper by

T. F. DAVIDSON
and
LT. J. H. WAY
Wright Air Development Center, USAF

UNDER controlled conditions, laboratory tests on seven MIL-L-7808 synthetic gas turbine oils indicate that improved correlation between laboratory and engine test results is needed if conclusions are to be valid.

For instance:

- Tests on thermal stability have been successful in predicting engine operation only when combination of coking at 600 F and WADC sludge rig test is used.
- Prediction of sludge formation has been successful only when the WADC sludge rig is used in the lab.
- The Ryder gear machine is the only test that gives satisfactory correlation of load-carrying ability. But it is too complicated, and simpler tests have not yet been devised which can give good correlation.
- Oxidation-corrosion tests which resulted in no corrosion in lab tests broke down and caused lead and silver corrosion in engine tests.
- The "H" rubber swell tests on elastomer attack do not give conclusive lab and engine test correlation.

In some respects, however, reasonable correlation has been found between lab and engine test results.

For example:

- Four-Ball wear test data obtained in the lab agrees excellently with engine results.
- Flash point and 400 F evaporation tests do good jobs of controlling consumption.

(Paper "Correlation between Laboratory and Engine Performance of Synthetic Turbine Lubricants" was presented at SAE Summer Meeting, Atlantic City, June 4, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

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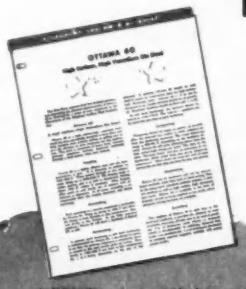

Write for a copy of the OTTAWA 60 BLUE SHEET

This Blue Sheet contains certified data on the physical characteristics of Ottawa 60, prepared from carefully checked laboratory and field service tests. All the information you'll need on methods of handling and heat treatment, etc.

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In fact, this exclusive Allegheny Ludlum-developed die steel is mighty *good* news for any user of draw dies. Ottawa 60 is a high-carbon, high-vanadium analysis, initially designed for the primary purpose of drawing stainless steel.

In that service, Ottawa 60 does just exactly what it was developed to do: it performs without galling or pickup, and shows exceptional wear-resistance—as a long list of successful applications will prove to you. Two of them are illustrated above: a stainless hinge and a stainless sundae server.

But Ottawa 60 is a top performer on any draw die application! Also illustrated above are the two draws on a transformer housing of .037″ gauge SAE 1010 strip. After more than 25,000 pieces—*over 12 times any previous runs*—there was still no sign of pickup, or of wear on the Ottawa 60 punch or die.

This analysis can solve your draw-die problem jobs—or reduce your costs on almost any drawing operation. ● Call on our Mill Service Staff for any assistance. ***Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.***

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AL® FINE TOOL STEELS SINCE 1854

Resins Gain Favor As Bearing Material

Based on paper by

A. J. CHENEY
W. B. HAPPOLDT
and
K. G. SWAYNE
E. I. du Pont de Nemours and Co.

"TEFLON" tetrafluoroethylene resin and "Zytel" nylon resin are now being used extensively for bearing material. Their behavior under little or no lubrication makes them promising for many applications.

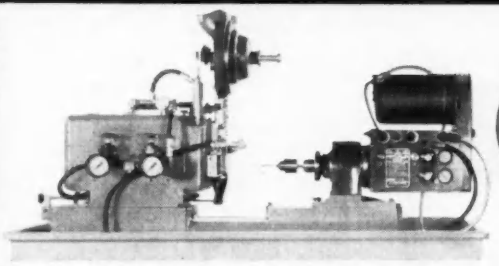
The most important of Teflon's properties is the low coefficient of friction—approximately 0.04 or less, under certain conditions—which can be obtained with non-lubricated bearings. These low coefficients can be had even with compositions containing fillers to improve wear properties. The resin has the highest melting point of any of the thermoplastics, melting at 620 F. It has excellent stability even at high temperatures and can be used continuously at temperatures up to 500 F and intermittently up to 620 F. Because it is a soft but tough material it will embed the hard foreign contaminants that are often found in a bearing.

Teflon is inert to a wide range of chemicals and solvents. Exceptions are molten alkali metals and fluorine at elevated temperatures and pressures. Water has no effect on it. Combinations with reinforcing agents such as graphite or powdered glass are used commonly for bearings and other mechanical applications requiring good resistance to wear. In general, the physical properties of these combinations are like those of straight Teflon except for having better resistance to deformation and wear.

"Zytel" nylon resin is being used for bearings ranging in size from a 1/16 in. inside diameter clock bearing to an 8 in. bearing used in the valve mechanism of a flour-carrying hopper car. Elevator car gibs of Zytel have been used for years, run against dry rails, which means elimination of the fire hazard due to lubricant. Zytel 101 is the highest melting and stiffest of the commercial nylons. Its coefficient of thermal expansion is several times as large as for the metals often used in bearing applications.

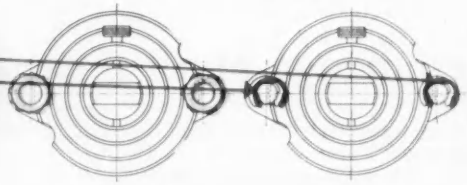
All nylons are hydroscopic and will pick up moisture until a condition of equilibrium is reached. Since the best moldings are produced when the molding powder contains less than 0.3% water, moldings as produced will absorb water. This requires that they be moisture conditioned to or near the equilibrium condition. Once the changes have taken place, further change due to normal variations in environment is small. Annealed bearings exposed to either 50% relative humidity air, or to water, show a dimensional growth for the first few months, after which the change is small. Bearings exposed to room con-

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



Beco Model 410 Drill and Tapper

The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



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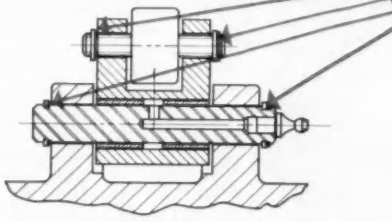
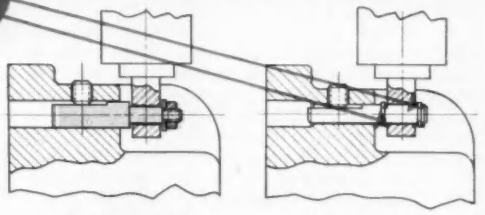
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



ALTERNATE DESIGN TRUARC DESIGN

Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting...plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

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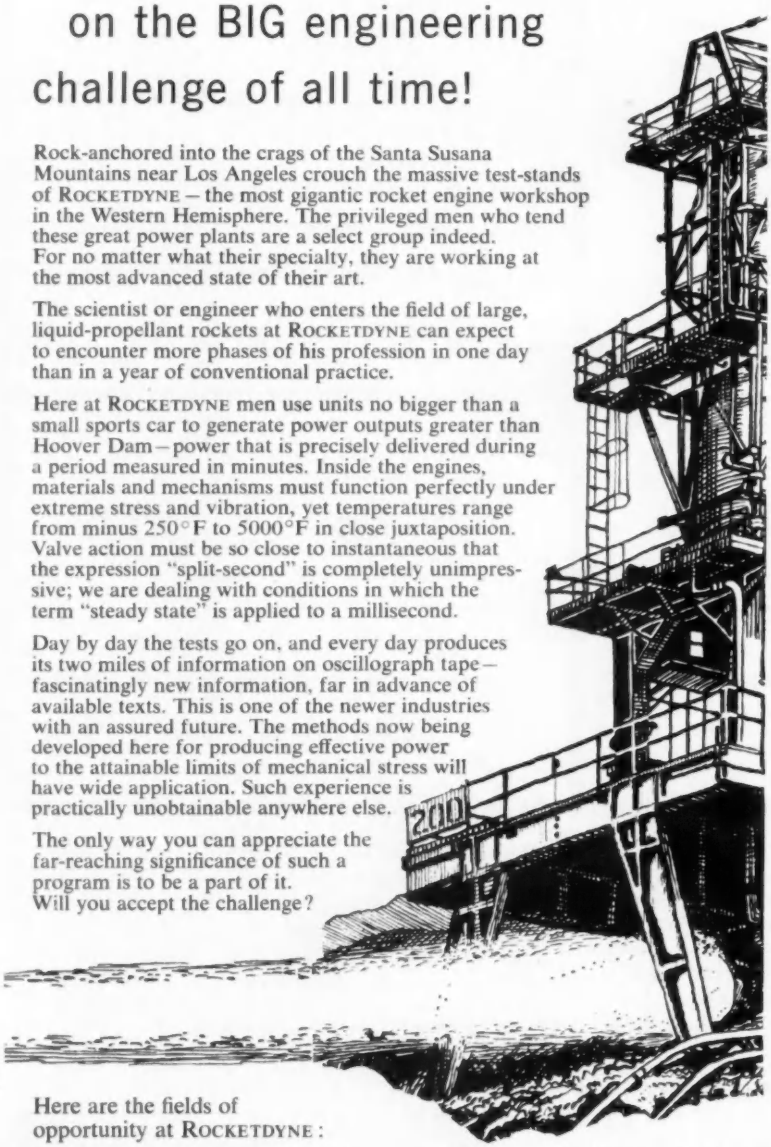
The only way you can appreciate the far-reaching significance of such a program is to be a part of it. Will you accept the challenge?



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ditions for one year with normal variations in relative humidity changed less than 0.001 in. per in. after initial growth.

The following comments should aid in choosing between Teflon and Zytel for bearings:

1. At room temperature, Zytel is much harder, stronger, and more resistant to abrasion and deformation than Teflon. The reverse is true at elevated temperatures. If the expected operating temperature is relatively low, Zytel is the strong candidate.

2. Teflon can be used absolutely dry; Zytel should preferably be given some lubrication. If lubrication is impossible, Teflon is often the choice for severe speed conditions since its coefficient of friction is less than that of unlubricated Zytel.

3. Zytel has good resistance to most liquids and seldom encounters difficulties of this nature. Where severe conditions do exist, Teflon is preferred. This is illustrated by its use on pumps and centrifuges handling acids.

The performance of Zytel with lubricant present has proved surprising. High loads at medium to high speeds can be supported by what apparently is hydrodynamic lubrication even though little lubricant is present. This opens an entirely new field of application for bearings made of this resin. (Paper "Zytel Nylon Resin and Teflon Tetrafluoroethylene Resin as Bearing Materials" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

P. C. Forrester
and
D. C. Mitchell, The Glacier Metal Co., Ltd.

Porous metal bearings impregnated with polytetrafluoroethylene (Teflon and Fluon) have been developed in England. Most laboratory and field experience has had to do with steel-backed bushes with a 0.010 in. layer of porous tin bronze, impregnated with Fluon and surface coated with a 0.0005 to 0.0015 in. layer of Fluon. Both metal and resin are continuous. The continuous metal phase confers good thermal conductivity, strength, and dimensional stability, while the continuity of plastic ensures that it is all available to the bearing surface for its wear and antifriction qualities. The steel backing further assists heat conductivity and mechanical strength.

In bearing operation the initial surface layer soon becomes very thin, part of the resin being transferred to the mating surface. If damage occurs to the thin resin film on either member, the resulting temperature rise causes expansion of the resin held in the metal matrix. Resin then exudes and heals the damaged area. During operation, both surfaces usually acquire a greenish tinge.

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X-Ray Saves Money In Airplane Inspection

Based on paper by

ALBERT D. EDWARDS
Delta C and S Airlines, Inc.

DELTA uses x-ray for checking condition of wing stringers, or primary structural members, in the fuel tank areas of its DC-6 and DC-7 airplanes. This is a very critical area for strength and safety as well as a difficult place to inspect properly by visual means. Much of the area within the tank is covered with a sealant which makes inspection most difficult unless it is removed. The subsequent replacement of sealant and the almost inevitable fuel leaks that follow, make the operation objectionable. With x-ray a complete inspection of these areas can be made without removing anything but the fuel. Often we find a previous repair may need attention, loose rivets may need replacement, or mechanic's malpractice may be uncovered. Knowing that hidden error will be detected has raised the standard of our mechanics' work.

The difference in cost between x-ray inspection and opening of wings, with fuel tanks and cells, at routine inspection alone is sufficient to pay for all equipment needed in the first year of operation. To remove and replace the leading edge for inspection of the heater duct in the horizontal stabilizer cost $67.50, whereas by x-ray the cost is only $6.38.

X-ray will not do everything, and the hazard of radiation must be kept constantly in mind. But it has its place in reducing time and labor costs and promoting safety by doing a better job. (Paper "Radiography of Aircraft Structure for Safety and Economy" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Discussion

Question: Does it require much skill to interpret x-ray pictures?
Answer: It does require experience. You have to get it by examining x-rays and build up the experience from looking at known imperfections. If you can define the edges of the metal beforehand and separate different sections, it is a big help in reading prints.
Question: What about inspection of spar webs?
Answer: Spar webs or caps can be x-rayed by placing film parallel to skin on under side of the wing and shooting down. You can see a crack up to a 45 deg angle, but it is better to be closer to the perpendicular.

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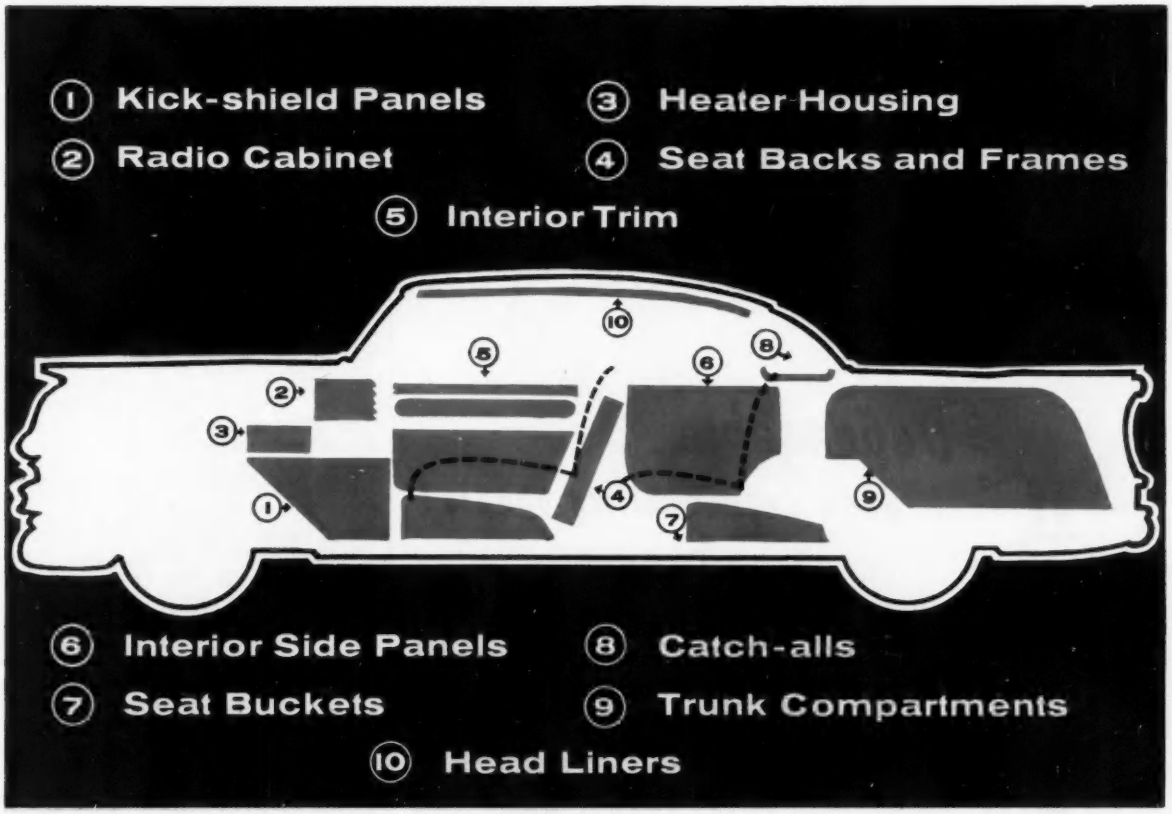
THE balanced-diaphragm remote plotter automatically records engine cylinder pressure versus crank angle.

This instrument possesses three im-

Naugatuck Marvibond



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portant features which eliminate the major disadvantages inherent in previously developed systems:

1. The curves plotted by the instrument are obtained on a statistically sound basis and are truly representative of many engine cycles.

2. It automatically records the pressure versus crank angle curve with equipment located remote from the engine, without operator attention other than for initial adjustments, and with a minimum of installation complexities.

3. The data are recorded in continuous analog form, to a relatively large scale, on standard strip chart paper.

The general function of the balanced-diaphragm remote plotter is to regulate a reference pressure to that value which exists within the engine cylinder at a specific crank angle and to record the resulting relationship. The instrument is composed of several circuits

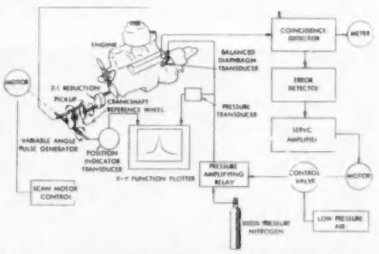

Fig. 1—Basic block diagram for balanced-diaphragm remote plotter.

which are arranged in two functional networks:

1. An electronic-pneumatic servo loop, which is technically a combination of an on-off servo and a sampling servo.

2. A recording system which has no effect on the servo loop operation.

The relationships of the component circuits are shown in the basic block diagram (Fig. 1). The servo loop components include the crank angle pulse generator, balanced-diaphragm transducer, coincidence detector, error detector, servo amplifier, servo motor, and pressure regulating system. The recording system includes the position transducer, pressure transducer, and function plotter.

The crank angle pulse generator is driven by the engine crankshaft and produces a sharp pulse once every 720 deg of crankshaft rotation. A crankshaft reference wheel (see Fig. 1) is rotated at camshaft speed through a 2.1 reduction. A single tooth on the circumference of the wheel passes very close to a capacity pickup once each revolution. A sharp capacitance change then occurs between the pickup and electrical ground. The crank angle at which the capacity pulse occurs is dependent upon the angular position of the pickup. The pickup can be positioned by a motor which is controlled by the scan motor control circuit.

The balanced-diaphragm transducer is a precision differential pressure switch. The transducer is mounted in an opening in the cylinder head of the engine so that one side of its diaphragm is exposed to cylinder pressure while the other side is exposed to an external reference pressure. The transducer completes an electrical circuit whenever the cylinder pressure exceeds the reference pressure.

The crank angle pulse and the balanced-diaphragm signal are coupled to the coincidence detector. If the crank angle pulse is generated when the balanced-diaphragm "switch" is closed, a coincidence pulse is produced. However, if the two signals do not coincide, no pulse is produced.

The coincidence pulses are coupled

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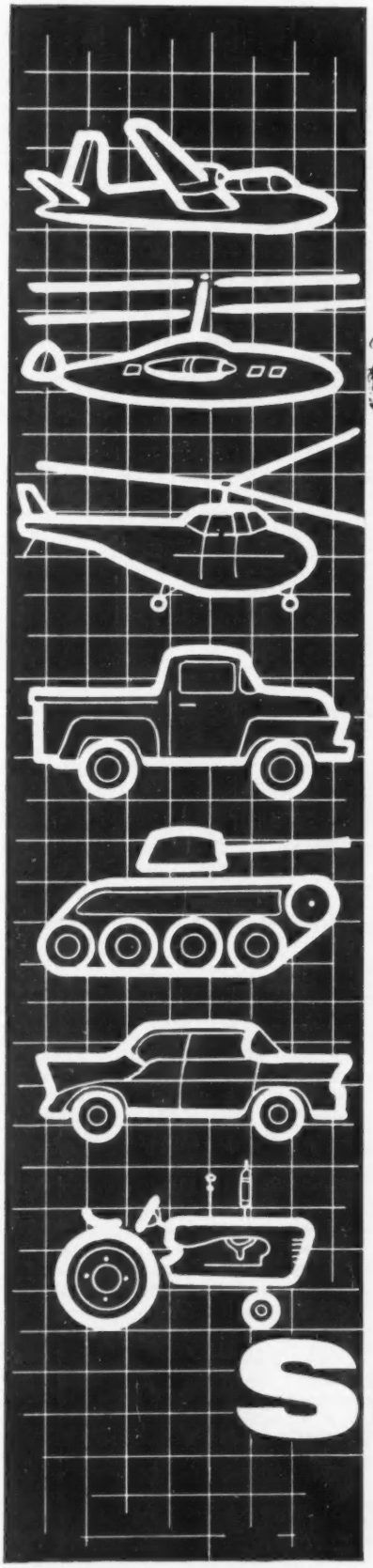

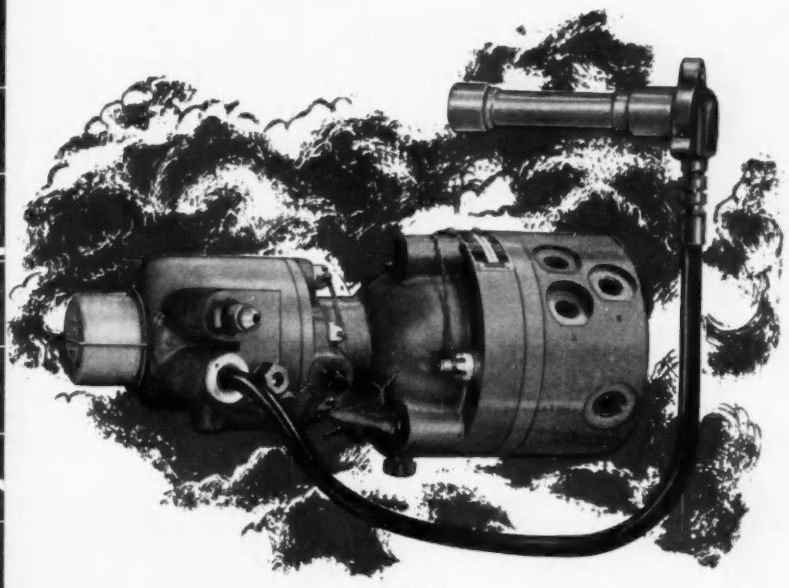

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A multiple point, low-pressure, timed, speed-density injection system, Simmonds SU Fuel Injection offers these proven advantages: it overcomes major icing problems to give improved cold starts; it eliminates the need of hot-spots and pre-heaters and simplifies manifold ducting; it provides increased power output due to removal of intake obstructions. The Simmonds System also provides improved fuel distribution and better cylinder head cooling — its operation is not affected by engine attitude.

Complete information on SU Fuel Injection Systems will be supplied on request.

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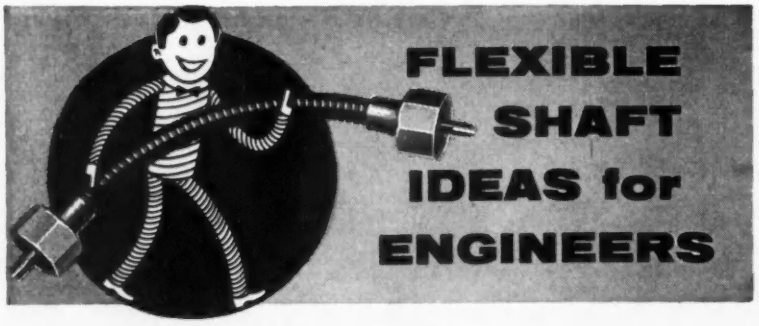

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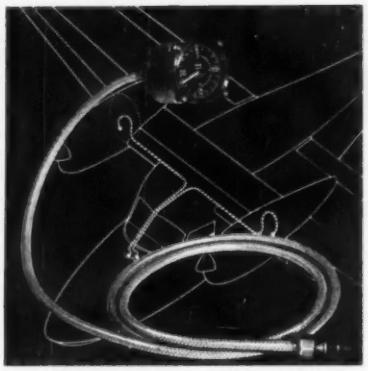


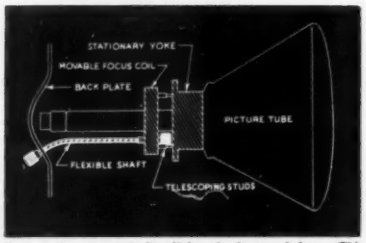
A flexible shaft tachometer drive application.

Save time and costs

Power sources and driven members or controlled parts and their controls can be positioned to better advantage. Costly methods of connection and adapting can be eliminated and general overall design can be improved. And, because an S.S.White flexible shaft does away with alignment problems and reduces the number of parts required for a control or power drive, costly and time-consuming assembly operations can be avoided.

Early consideration best

By far the best time to consider using S.S.White flexible shafts is when your product is still in the design stage. Then



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to the error detector, where they are averaged, producing a d-c voltage, which is a function of the number of coincidence pulses generated per engine revolution. The coincidence rate may be expressed in per cent; 100% is equivalent to one pulse per engine cycle.

The d-c level is applied to a servo amplifier, which controls the speed and direction of a servo motor. The motor operates a pressure regulating system, which includes a control valve and a pressure amplifying relay.

The control valve output pressure varies from 0 to 50 psi, depending on the angular position of its input shaft, driven by the servo motor. This pressure is used as the control pressure for the pressure amplifying relay. The output pressure of the relay is 30 times the control pressure, or 0 to 1500 psi. The regulated high pressure is the reference pressure for the balanced-diaphragm transducer.

(Paper, "Instrument for Recording Cylinder Pressure versus Crank Angle of Internal-Combustion Engine," was presented at the SAE Annual Meeting, Detroit, Jan. 12, 1956. It is available in full in multilith form from SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.)

THE crank-angle-time recorder makes a permanent record of the time (in crank-angle degrees) at which various combustion phenomena occur in the engine cycle.

The recorder can be used in conjunction with either of the following instruments:

1. Total surface-ignition counter.
2. Audible surface-ignition counter.

It is used with the total suface-ignition counter (described earlier by Hirschler et al.[1]) when it is desired to determine when individual flame fronts from either normal or deposit-ignited combustion arrive at anionization gap in the combustion chamber.

When used with the audible surface-ignition counter (described in an earlier paper[2]), it records the time in the cycle when audible manifestations of both knock and knocking surface ignitions occur.

Fig. 1 shows a block diagram of the electrical circuits for the recorder with total surface-ignition counter. The recorder uses the ionization signal received by the counter to trigger a spark generator, which jumps a spark between an electrode and a crankshaft-

[1] SAE Transactions, Vol. 62, 1954, pp. 40–49: "Deposit-Induced Ignition—Evaluation in Laboratory Engine," by D. A. Hirschler, J. D. McCullough, and C. A. Hall.

[2] SAE Transactions, Vol. 63, 1955, pp. 53–62: "Practical Yardsticks for Deposit Effects," by C. A. Hall, J. A. Warren, and J. D. McCullough.

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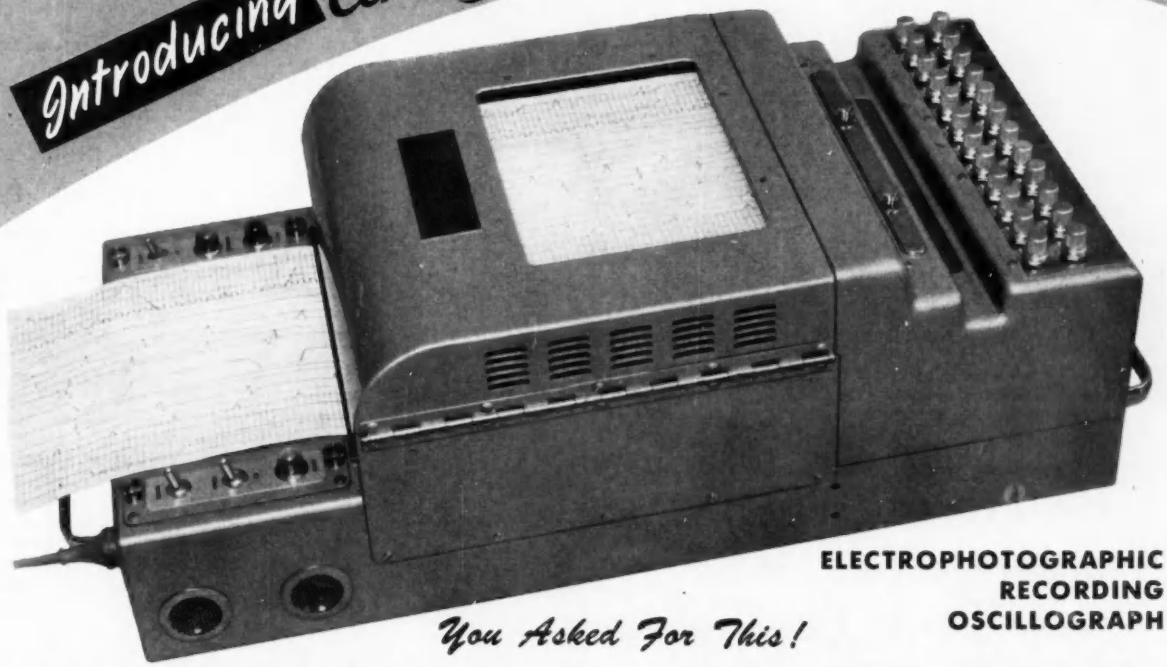

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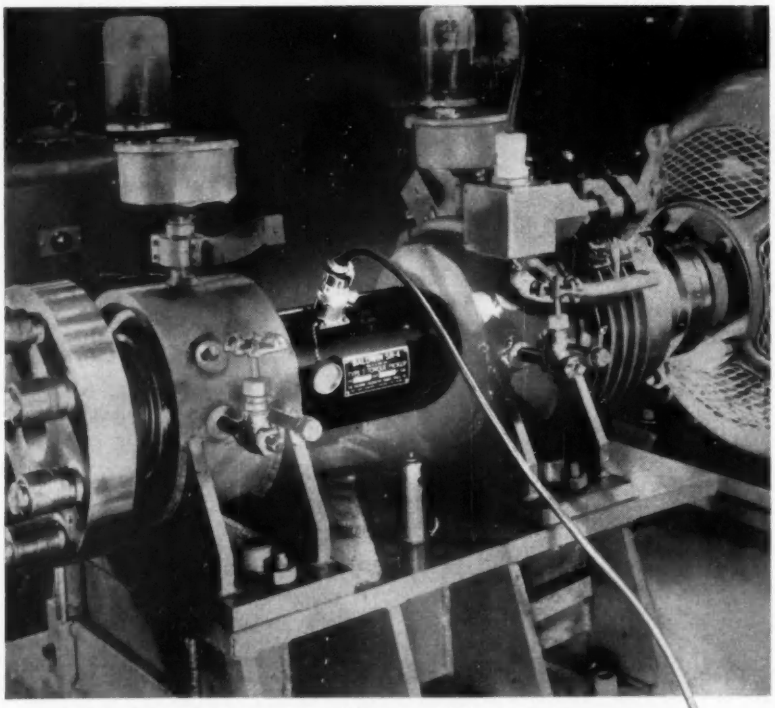

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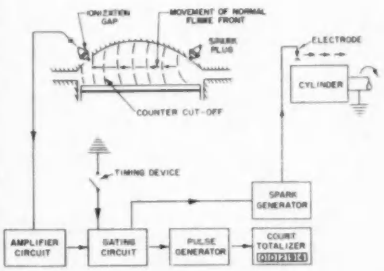


Fig. 1—Block diagram of electrical circuits for crank-angle-time recorder.

driven cylinder covered with sensitized paper.

It is possible to show each individual ionization as a dot on the sensitized paper at the same instant when ionization occurred by moving the electrode along the longitudinal axis of the cylinder. Visual inspection of the paper record gives the crank-angle degrees in the cycle at which the gap was ionized. Regulation of the camshaft-driven timing device allows a record to be made of either surface ignitions or normal combustion. (Paper, "New Instrumentation for Engine Combustion Studies," was presented at the SAE Annual Meeting, Detroit, Jan. 12, 1956. It is available in full in multilith form from SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers. This paper will also be published in full in SAE Transactions.)

High Speed Tire Meets Growing Need

Based on paper by

M. P. HERSHEY
Firestone Tire & Rubber Co

THE higher top speed of new cars, increased tire loads, improved highways, and the mounting popularity of sports cars have created the need for a high performance tire. Such a tire is made with a high strength cord body which will withstand impacts even with elevated inflation pressures and will give better car handling especially at the higher speeds. Several are now on the market.

For best high speed performance, use a tire as large as is practical. For a given speed, the larger the tire the fewer the revolutions per mile and the cooler the tire. It is also desirable to

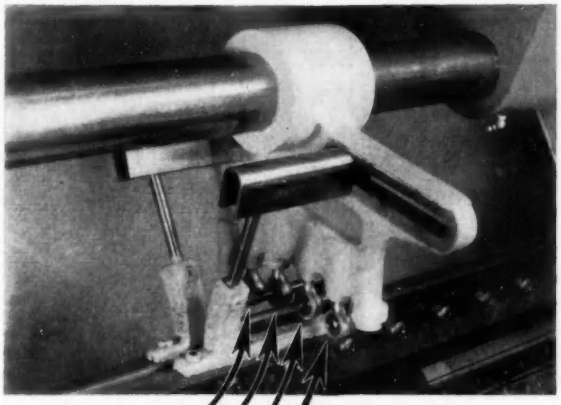
THE SURPRISINGLY VERSATILE

HEIM Unibal

Suspension Hangers ... right out of stock!

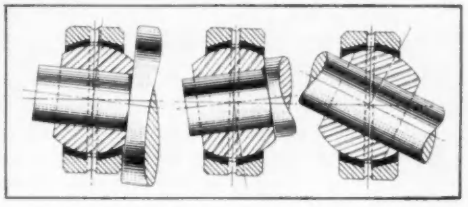
HAS MANY USES OTHER THAN STRICTLY ROD END APPLICATIONS

Because of the very name of the piece, we think of a "rod end" as a sort of universal joint at the end of a rod when used in a linkage mechanism for pull-push operation. And for transmitting motion at varying angles, the Heim Unibal Rod End is the most dependable and most efficient of all.



However . . .

the ability of the Heim Unibal to correct misalignment in any direction, the smoothness of its oscillation, and its low cost, are just the qualities looked for in some unusual shaft supports.



HEIM MALE ROD END

Take this Kidde Knitter as an example of how Heim Unibal Rod Ends have been used as suspension hangers for the guide bars. It is essential that these bars move laterally, both smoothly and freely.

The hanger arm is drilled and tapped, and the male Heim Rod End is screwed into place. Assembly is simple, yet alignment of the bars is positive, and vertical adjustments can be made quickly and easily.

Perhaps you have a place where Heim Rod Ends can improve mechanical function and cut the cost of parts and assembly. Submit your problem to the HEIM engineering department for advice and assistance.

THE HEIM COMPANY | FAIRFIELD, CONNECTICUT

use higher than normal inflation pressure since it reduces deflection and flexing and thus lowers running temperature.

Overloads have a detrimental effect on performance. Partial compensation for this can be made by increasing inflation pressure to maintain the same percent deflection. Heat build-up can be cut from 15 to 8 F by using 32 instead of 24 psi for 20% overload. Maintenance of deflection is not the entire answer because higher intensity of pressure per square inch of ground contact area means greater stress in the rubber with consequent heat generation. (Paper "New High Speed Tires" was presented at SAE Passenger Car, Body, & Materials Meeting, Detroit, March 8, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

NEW IMPROVED
ELECTRONIC TACHOMETER for
EXTREME ACCURACY

Plus or Minus 1 RPM at
Speeds from 10 to 50,000 RPM

No other tachometer or revolution counter is more accurate — more dependable. Revolutions are converted to electrical pulses by the tachometer generator. The Electronic Tachometer counts them accurately for precisely one second and displays the count directly as *revolutions per minute.*

DESIGN EMPHASIS WAS PLACED TO GIVE YOU THESE OUTSTANDING BENEFITS:

★ **EXTREME PRECISION** — Oven-controlled crystal is accurate to 1 part in 1,000,000.

★ **RELIABILITY** — Circuits designed for *continuous service.* Number of vacuum tubes kept to a minimum.

★ **EASY-TO-READ** — Brilliant glow-spots can be read in brightly lighted rooms. Display time is adjustable from .5 to 10 seconds.

★ **SELF-CHECKING** — Frequency Standard has built-in feature to let operator check accuracy of instrument at any time.

★ **MAINTENANCE** — Package-type plug-in construction simplifies servicing.

Write today for complete details. Ask for Bulletin #240.

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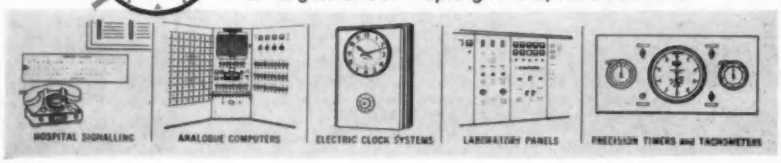

Chevrolet L-4 Test Due for Modification

Based on paper by

DR. R. J. DeGRAY
The Standard Oil Co. (Ohio)

THE L-4 test, based on the six-cylinder Chevrolet engine, has a definitely limited future, but before attempting a replacement it would be wise to determine what parts of it are worthy of retention and what needs to be improved.

Study of some of the L-4 data in our files led to the conclusion that three items deserve to be retained. These are:

- The basic concept of a high-temperature engine test.
- The additivity of the contributions of the components of the oil to the overall performance.
- The general method of rating the dirtiness of the several engine parts and their combination into a composite figure.

By the same token, there are four elements of the L-4 test that call for correction or improvement. These are:

- The fuel needs better standardization.
- The bearing weight less procedure requires modification so that it measures the loss due to the action of the oil or its deterioration products.
- The rating system should be changed to make error either independent of rating, or proportional to it.
- The entire procedure needs tightening to enable effects of engineering importance to be measured with statistical significance.

In the process of arriving at the above mentioned conclusions, a method was developed for spotting bad engine runs and validating good engine runs purely from the results of the run itself. Of the many relationships we were able to establish three were found to identify "bleepers" without prior knowledge or duplicate tests. These three provided equations which will spot bad rating of engine parts, peculiar deterioration of the oil (either too much or too little), and peculiar bearing weight loss. If all three equations are satisfied by the test results, the entire run may be considered valid.

The merit of this method lies in the avoidance of expensive re-testing except in the case of a bad run, as well

How Great Lakes Steel *launches* quality

You're at 400 feet, banking for a good close look at the unloading operation of the *Ernest T. Weir*. She's packed to the gunwales, stem to stern, with ore—tons of iron-bearing food for Great Lakes hungry blast furnaces.

What's this got to do with turning out top-quality steel at Great Lakes? Plenty! For quality pig iron can come only from quality raw materials—like the *Weir's* rich cargo. And, of course, quality pig iron is the very backbone of top-quality steel.

Control of quality at Great Lakes begins right at the mines. In fact, each ore source is picked with painstaking care. Then, repeated checks in the mines—*double checks* here at the unloading docks—put the quality of Great Lakes raw materials beyond question!

It's that kind of control (from start to finish) that gives our flat-rolled products uniform quality—assures that they will reach our customers exactly when and as ordered. We're ready to talk your steel needs whenever you are.

GREAT LAKES STEEL CORPORATION

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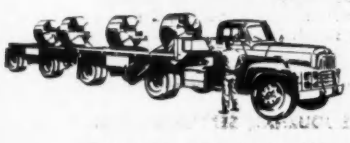

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SAVE MONEY!

If you've got a product involving metal fabricating, fastening or assembling, chances are you can use Midland Welding Nuts to big advantage.

They come in all sizes for every-sized job. Welded to the part or parts concerned, they don't have to be held while bolts are turned into them. Thus one man can often do the work of two.

And they're indispensable when it comes to those tucked away, hard-to-get-at places. Welded in advance to those inside spots where it is difficult—or *impossible*—for hands or tools to reach, Midland Welding Nuts hold fast while bolts are turned into them.

If you're a designer, you'll want to know about these time and labor-savers, too. Midland Welding Nuts will solve and simplify many of *your* problems, too.

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as in the saving of the still greater expense of a poor decision based on a bad run.

In addition, factors were developed whereby the L-4 rating can be calculated as precisely as the engine could measure, given known base oils and additives. (Paper "The Chevrolet L-4 Test: What Does It Measure?" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1956. It is available in full, including the three equations mentioned above in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Improved Cold Starting On New Mack Diesel

Based on paper by

W. J. PELIZZONI

Mack Mfg. Corp.

COLD-starting tests of the Mack Thermodyne open-chamber, direct-injection diesel engine show it to be superior in this respect to the earlier energy-cell engines. As shown in Fig. 1, the open-chamber engine has superior starting ability at all cranking speeds. The data in this graph were recorded during cold room tests at 32 F, without any starting aid. The electrical system on these diesel engines provides cranking speeds of 150–200 rpm at freezing and below freezing temperatures. Thus, satisfactory starting is assured in a minimum of time. (Paper "Mack END Thermodyne Diesel" was presented at the SAE Pittsburgh Section, March 27, 1956. Presentation was made by Merrill C. Horine, Mack Mfg. Co.)

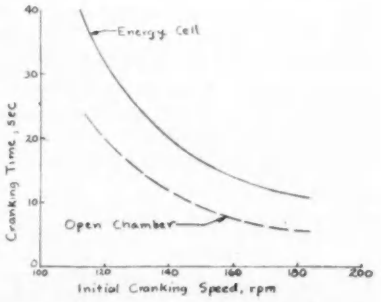

Fig. 1—Cold-starting ability of open-chamber engine is superior to that of energy-cell engine at all cranking speeds

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VISION-AID HEADLAMPS

5040-S for 6 volt passenger cars
5400-S for 12 volt passenger cars
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WITH E·Z AIM PLATFORMS

FOR USE WITH ANY APPROVED AIMING DEVICE

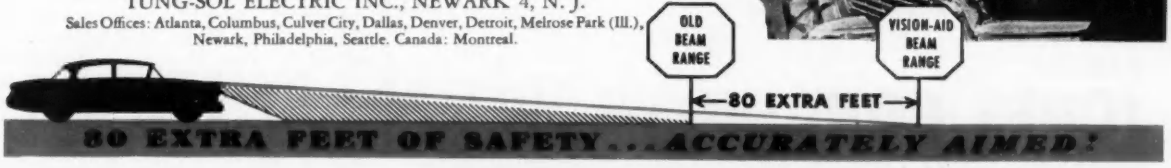
The new improved Tung-Sol Vision-Aid Headlamp can be quickly adjusted with any approved aiming device—or can be aimed visually. Three E-Z Aim Platforms, precision-molded on the face of the lens, provide contact points for all the new mechanical aimers. They assure accurate beam adjustment in a matter of minutes—even in broad daylight. These headlamps are fully interchangeable with all sealed beam headlamps of the same voltage.

Car owners benefit from wonderful new safety features of all Vision-Aid Headlamps: The new, more powerful beam gives 80 extra feet of seeing distance down the right side of the road; the filament cap and new lens design improve visibility in rain, fog and snow.

They insure complete satisfaction for car manufacturers, because traditional Tung-Sol quality and nationwide distribution more than meet performance and service requirements.

TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

Sales Offices: Atlanta, Columbus, Culver City, Dallas, Denver, Detroit, Melrose Park (Ill.), Newark, Philadelphia, Seattle. Canada: Montreal.



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We are proud of our ability to reduce tooling costs to *little* or *nothing* on normal bonding jobs.

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JONES BONDING AND MFG. CO.

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New Members Qualified

These applicants qualified for admission to the Society between July 10, 1956 and August 10, 1956. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Leslie A. Dulmadge (A), Sidney A. Smith (A).

Baltimore Section

Major Lef W. Kenyon (M), John N. Lyndall, Jr. (A), Angelo F. Palmisano (A).

Buffalo Section

Frank M. Baumgardner (M), Howard W. Brandt (M), Edward Kubic (M), R. Douglas Rumsey (M), Milton H. Van Alstyne (M).

Canadian Section

Alan C. Brierley (M), Elmer W. Carter (A), Richard B. Sharpe (A), Roger W. Wade (A).

Central Illinois Section

Walter R. Gutzwiller (J), Raymond H. Hays (M).

Chicago Section

Edward J. Beth (M), James R. Chapman, Jr. (J), Richard L. Durgin (M), Duke A. Garrison (A), William L. Green (M), Donald E. Hobson (M), Robert C. Holmberg (A), Max L. Howard (J), Leon C. Hummel (J), Raymond C. Nelson (M), Alvin G. Phillips (M), Malcolm A. Sime (M), Samuel R. Stiefel (A).

Cincinnati Section

J. S. Sampselle (M), Horace F. Yoder (A).

Cleveland Section

Vincent R. Barrord (M), Lawrence E. Biggs (M), Andrew S. Gill, Jr. (M), Clyde C. Logue, Jr. (M), Walter H. Robinson (M), Charles W. Wilhide (M).

Dayton Section

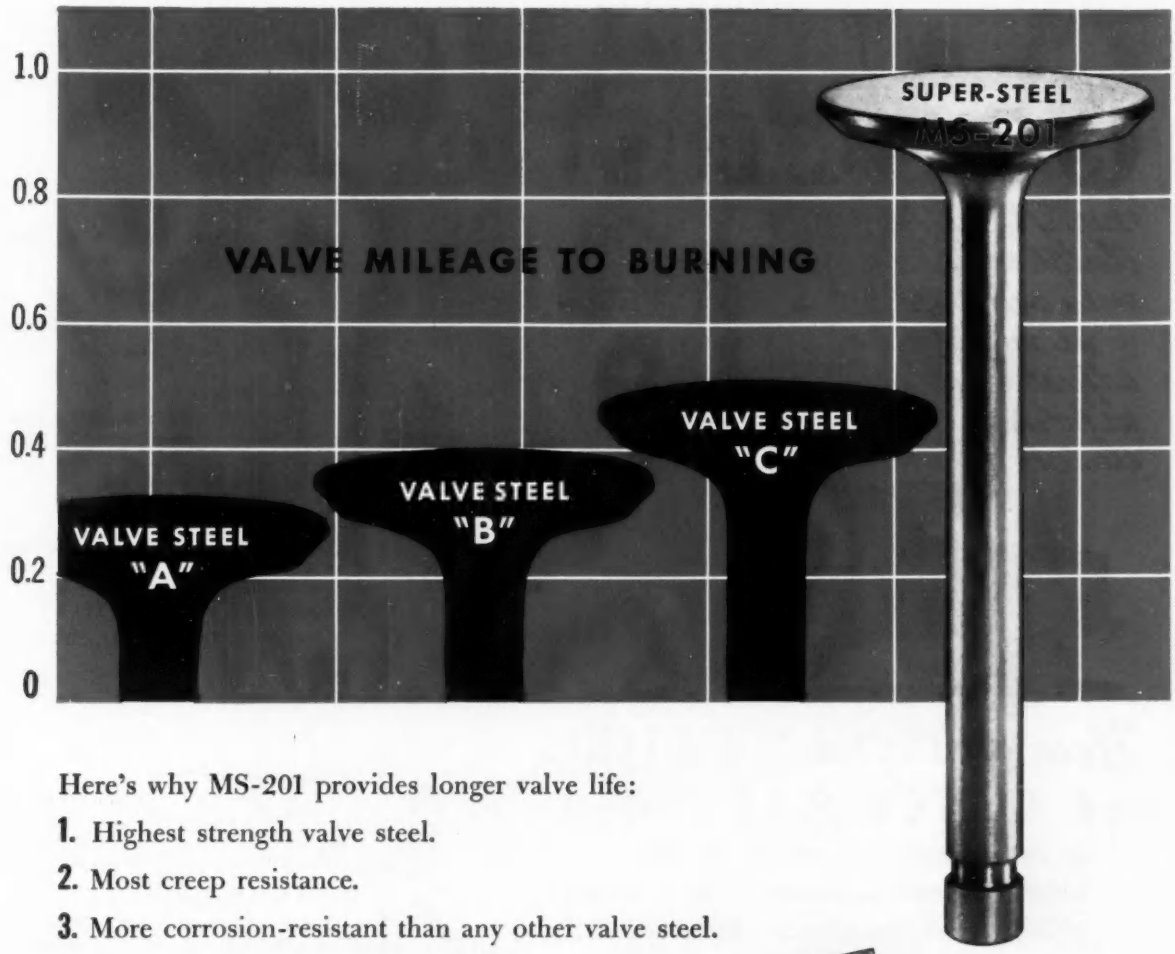
Paul E. Erbaugh (M), William R. Lamb, Jr. (J).

Detroit Section

John A. Alfes (J), Wayne S. Anderson (M), Albert M. Ankrom (M), James P. Brannan (A), William E. Brunsdon (J), Selden D. Burchenal, Jr. (M), Everett A. Butler, Jr. (J), Wayne E. Canfield (A), Phillip Dmetroshko (M), Richard L. Drake (A), Ferdinand R. Eichner (M), Martin A. Erickson (M), Alfred H. Erwin (A), Edwin Lee Etnyre (M), Thomas J. Foley (M), Robert J. Gorman (M), Richard M. Hindman (M), James R. Ignatowski (J), Frederic A. Jaques (M), William K. Jensen (M), Earl W. Jorgensen (M), George L. Mc-

Thompson's New MS-201 Alloy

Doubles Valve Life



Here's why MS-201 provides longer valve life:

1. Highest strength valve steel.
2. Most creep resistance.
3. More corrosion-resistant than any other valve steel.
4. Higher hot-hardness than any other austenitic alloy.
5. Highest room temperature hardness than any other austenitic alloy.
6. Lowest critical alloy content of any austenitic alloy.

The detailed story of this interesting valve development is featured in Thompson Products' Engineering Bulletin Vol. 1, No. 1.

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Allan R. Craddock (A), John M. Ross (M).

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Texas Section

D. H. Foley (A), Foster M. Poole (M).

Texas Gulf Coast Section

John G. Willard (M).

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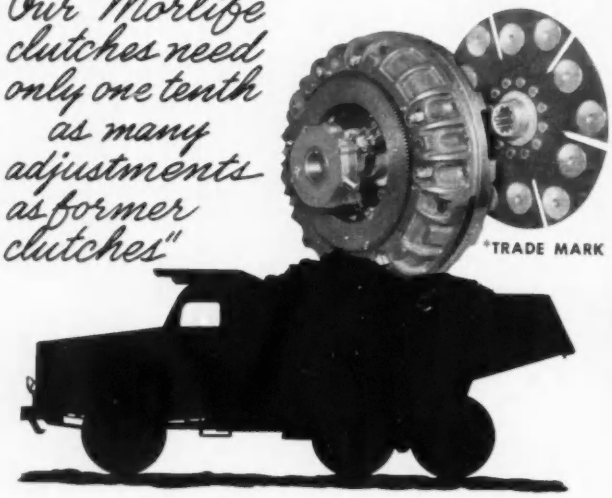

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"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE clutches last 950 hours longer, without adjustment."

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"MORLIFE pulls harder and lasts six to ten times longer."

"Won't buy a unit that isn't equipped with Durable MORLIFE clutch."

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These *new* ROCKFORD Clutches and Clutch Plates have been developed by ROCKFORD Clutch Engineers to take full advantage of recently discovered facing material. Actual field tests on heavy duty equipment have resulted in adoption of MORLIFE clutches by builders of tractors, earth movers, graders, shovels, cranes, trucks, oil field equipment and power units. For information how these *new* Rockford MORLIFE Clutches will improve the operation and increase on-the-job hours of heavy duty machines, write Department E.

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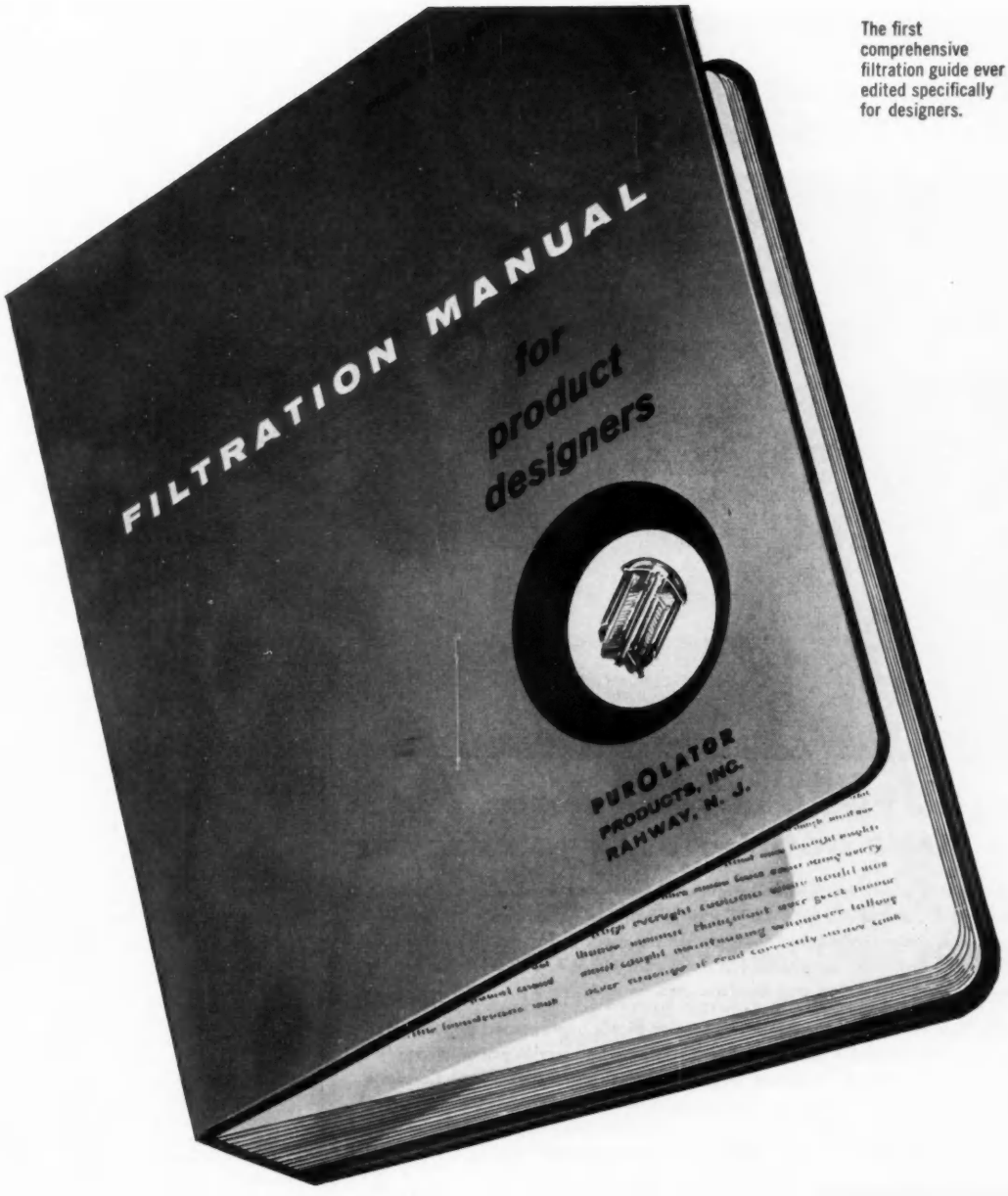
CLUTCHES



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Some typical section headings

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"Filtration Manual for Designers" spells out application considerations in detail including degree of filtration, flow rate, contamination to be removed, viscosity of fluid, plus a complete glossary of terms that apply to filtration. Printing of this manual is limited so please send in coupon for your copy today.

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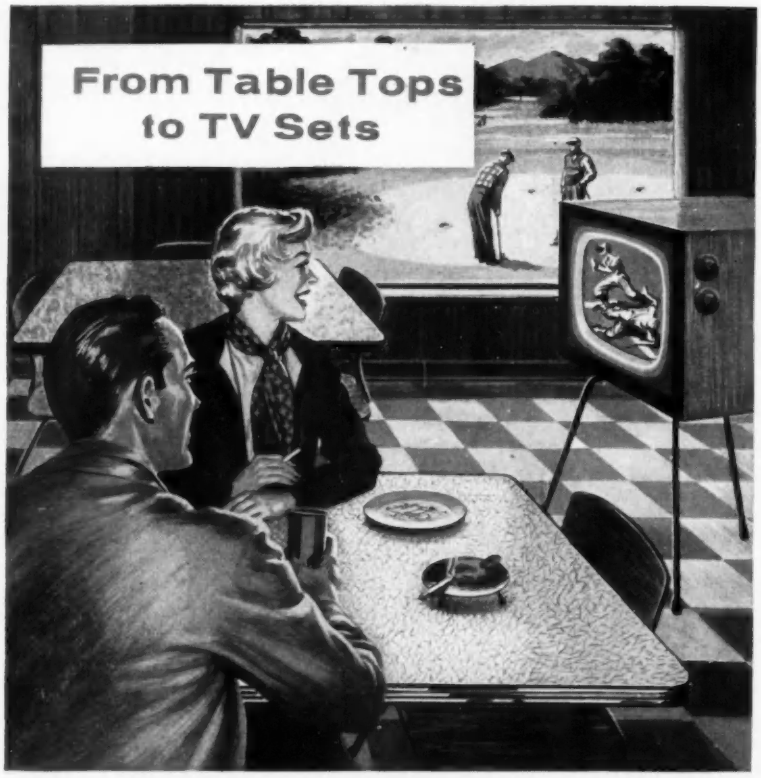

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When it comes to plastic impregnated papers for laminating or molding applications, you'll do well . . . *always* . . . to think of Fabricon *first!* First for melamine impregnated patterns, wood grains, solid colors, and translucent overlays for durable decorative laminates. And first, too, for phenolic impregnated N.E.M.A. industrial grades for countless electrical, mechanical and structural uses.

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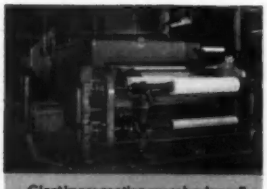

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Foreign

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Applications Received

The applications for membership received between July 10, 1956 and August 10, 1956 are listed below.

Atlanta Section

Charles L. Adams, Jr., James U. E. Cowie, John H. Eaton, Claude A. Ivey.

Baltimore Section

Harvey W. Selway, Lemuel O. Warfield.

British Columbia Section

George Curley, Henry C. Givins.

Canadian Section

George D. Clark, Theron B. Finley, Greig B. Smith, Horatio W. Thompson.

Chicago Section

Thomas F. Bamford, James F. Bueche, John H. Koerber, Joseph M. Lyons, William A. Mulcahy, Paul A. Myers, Charles K. Pursell, Joseph E. Risser, William G. Sheiry, Jr., Warren Wong.

Cincinnati Section

Aaron Komisar, Richard C. Rossow, Kenneth T. Wilbur.

Cleveland Section

Ralph W. Barnes, Edwin L. Fort, Frank H. Kramen, William H. Moyer, Andrew C. Palguta, Arthur D. Schultz.

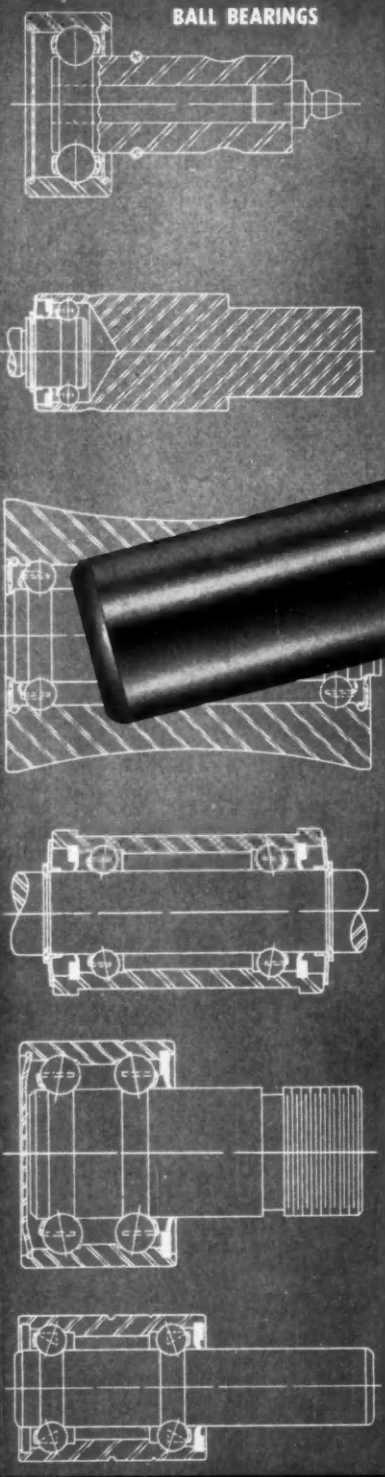
Dayton Section

Donald W. Frink, Jr., James A. Guild, James H. Tarter.

Detroit Section

Gerald G. Abbey, Ned A. Bania, Roger L. Berkbigler, John A. Berst, Robert E. Bonzack, William R. Carey, Arthur M. Christopherson, Thomas J.

SOME M-R-C INTEGRAL SHAFT BALL BEARINGS



M-R-C "Synthe-Seal" INTEGRAL SHAFT

BALL BEARINGS

Reduce manufacturing and maintenance costs—eliminate inner ring and shaft fitting problems.

- Bearings protected against dirt and moisture during installation and use.
- Prelubricated unit assures proper type and amount of grease.
- Cartridge type unit simplifies installation with minimum of parts.

When quantities warrant, bearings can be supplied with shaft extensions having machined holes, grooves, keyways, slots, shoulders and threads, and with pressed flingers, snaprings, collars or other parts mounted on them. Shaft ends can be supplied unhardened to be modified by customer if required.

M-R-C Engineers are available for consultation on your bearing problems.

M-R-C Strom SRB GURNEY BALL BEARINGS

MARLIN-ROCKWELL CORPORATION

Executive Offices: JAMESTOWN, NEW YORK

Check the response-to-the-touch. You can actually feel the difference!

That's why the Paragon Drafting Machine noticeably cuts end-of-the-day fatigue . . . saves costly man hours . . . helps raise working standards.

See how easily protractor control ring can be reached—no matter what position your hand is in. Another time saver. Touch that ring with your *little* finger and scales rotate freely. Release pressure and scales automatically lock to nearest 15° position. And intermediate angles are just as easily set!

Top day-to-day performance is guaranteed by unique "open center" design of arms which protects smooth-working factory-set band tension.

A good look at a Paragon and a touch on that control ring is worth 1,000 words! Try it before you buy *any* drafting machine—you can *feel* the difference.

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In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

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Applications Received

Continued

Clark, Jr., Jack M. Cudlip, D. Harold Davis, Jr., Frank L. Dempsey, Jr., Myron Dunn, Ralph C. Emig, Jr., John A. Ferrari, Suey Gene Y. Fong, Stuart M. Frey, James E. Friant, Lawrence E. Gaydos, George L. Giasson, William R. Haney, Jr., George C. Harbert, George C. Hargraves, Kenneth L. Hasselkus, William C. Hester, Raymond F. Hines, Robert M. Hodgson, Jack W. Hooper, Donald H. Iacovoni, Robert A. Jackman, Robert C. Kemp, John E. Kenealy, Charles C. Krueger, Jr., Maynard Lagassee, David Levitin, James Lunan, William M. Miller, Bluford L. Moor, Jr., D. F. Roth, R. E. Sawyer, William S. Shepard, Morris R. Steere, Leo G. Steini, Phillip Jay Walcott, Frank Wino, Bernard F. Woods, Jr., Alfred C. Wooll, Edwin L. Yates, Sanvus Yuen.

Hawaii Section

Anthony A. Arruda, Yoshiaki Tanaka, William B. Walter.

Indiana Section

Thomas E. Battle, William E. Freed, John E. Irwin.

Kansas City Section

Jack McCuaig, John W. Wyatt, Jr.

Metropolitan Section

Everett J. Adler, Warren E. Begas, Steve E. Colucci, D. Gardner Foulke, Mark L. Hessel, Joseph J. Kaufman, Howard G. Kurtz, Jr., Robert Kutrieb, Griffith May, Larry Mozzar, David O. Park, Dewey V. Sherman, William B. Silvestri, Jr., Alfred W. Siman, Hans U. von Borcke, Lee Ronald Webster, Richard S. Wolff.

Mid-Continent Section

Richard W. Hurn, Bill Mitacek, Jack L. Stout.

Mid-Michigan Section

Paul R. Clark.

Milwaukee Section

Royal F. Bandemor, Robert F. Bierman, Herbert Geissler, Ronald J. Klatt, Philip F. Peterson.

Mohawk-Hudson Section

James O. Blanton.

Montreal Section

Hugh W. Douglas, Bernard Lanctot, P. J. Todkill.

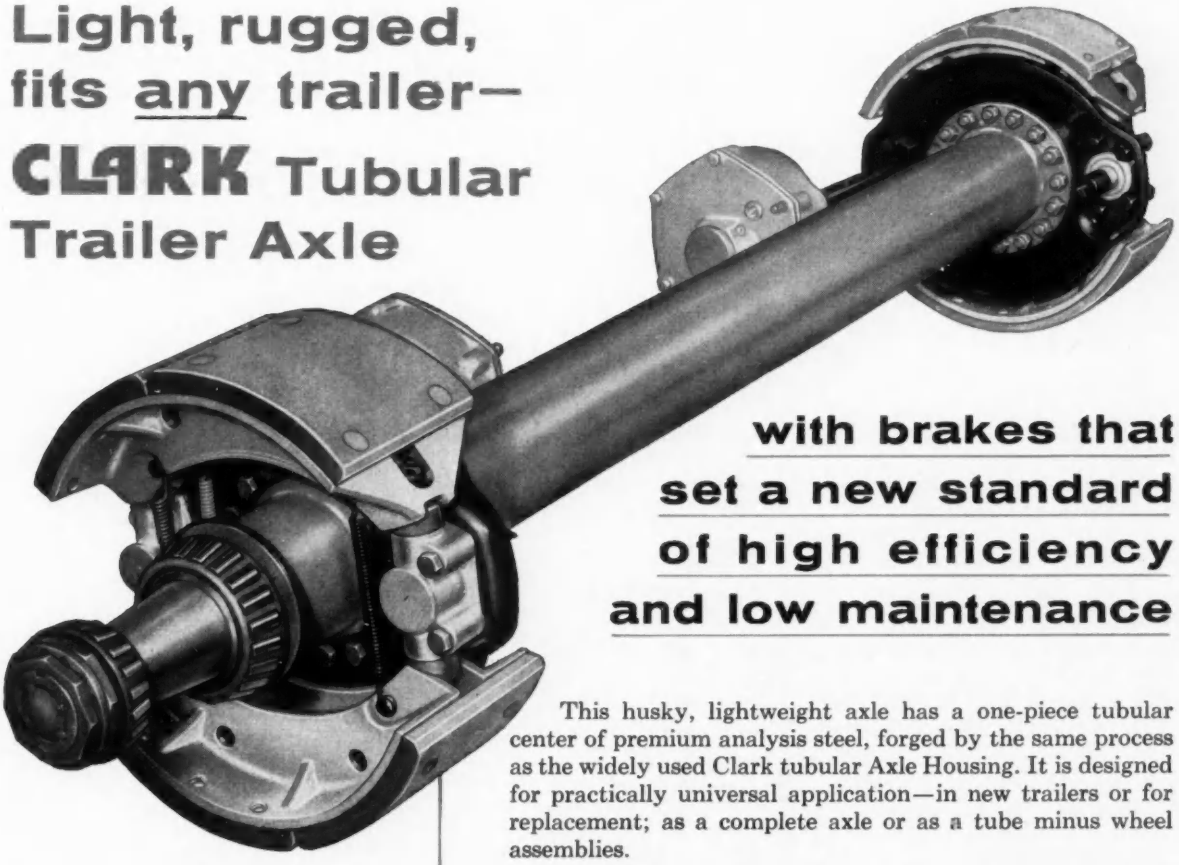
New England Section

George P. Dinell, F. Cort Turner.

Northern California Section

Robert H. Duke, Jr., Robert L. Friedman, Edwin R. Hanson, David R. Jones, Robert Lee Woolf, E. Bruce Wright.

Light, rugged, fits any trailer— CLARK Tubular Trailer Axle



with brakes that set a new standard of high efficiency and low maintenance

This husky, lightweight axle has a one-piece tubular center of premium analysis steel, forged by the same process as the widely used Clark tubular Axle Housing. It is designed for practically universal application—in new trailers or for replacement; as a complete axle or as a tube minus wheel assemblies.

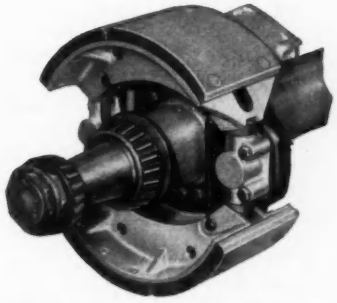
- Revolutionary brakes establish new standards for high operating efficiency and low maintenance. No slack adjusters or cam shafts. Brake actuators for air, hydraulic, vacuum or air over oil; all mountable at same location—minimizing inventory requirements.

- Two sizes:
  ND 18000—½ inch section, 5-inch OD
  ND 20000—⅝ inch section, 5-inch OD

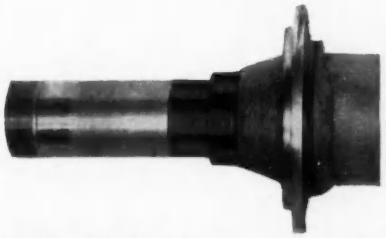
Standardized spindle dimensions make all wheel and brake parts interchangeable for both sizes, and also interchangeable with axles of other makes. Inventory needs are reduced to a minimum.

Brake linings and shoes can be removed for servicing without disturbing actuators.

As a practical, common-sense step toward more profitable trailer operation, send for the helpful Clark Trailer Axle Bulletin. Use the coupon.



Advanced Brake Design—both shoes are equipped with bell cranks and push rod; and provide Two-Leading Shoe effectiveness for highly efficient braking action in both Forward and Reverse. No stationary pivots—shoes have no fixed location, are free to slide; allowing full lining contact and compensation for wear.



Induction Hardening—For extra strength at a common area of failure, the inner wheel bearing surfaces are induction hardened, increasing the fatigue factor by 400 per cent.

CLARK® EQUIPMENT

CLARK EQUIPMENT COMPANY
Buchanan 5, Michigan

Please send bulletin on Clark Trailer Axle.

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COMPANY_____ POSITION_____

ADDRESS_____

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NORTH AMERICAN AVIATION, INC.

at Downey, California

(North east of Long Beach)

offers stability, top salaries,
and advancement potential
in the following positions

MISSILE DEVELOPMENT DIVISION AT DOWNEY

WRITERS, CONTRACT SPECIFICATIONS—ME, BS or BA DEGREES REQUIRED. Sufficient industrial experience for adequate working knowledge of Estimating, Contract Administration, Engineering Design. Familiarity with Government Specifications affecting design problems. Systems involved: Electrical, Electronic, Electro-mechanical, Pneumatic and Hydraulic, including Structures (combinations especially valuable). Journalistic training an asset.

STANDARDS ENGINEERS—BSEE or BSME. Writing training helpful. Work with Manufacturing and Engineering Depts., to review original designs or re-work. Survey Standards procedures from practical shop standpoint. Prepare technical data for manuals, interpret Standards information, evaluate practicability of Govt. and NAA Standards best suited to company needs.

SENIOR ENGINEERS DRAWINGS CHECKER—Degrees in ME or EE (ME preferred). Experience in electrical or mechanical design and manufacturing standards and procedures in aircraft or missile work preferred. Other experience may be adaptable.

AUTONETICS DIVISION AT BELLFLOWER

CIRCUIT STANDARDS ENGINEERS—Specialists in Electronic Circuits to coordinate establishment of Standard Circuits as may be used in equipment for Guidance, Weapons Director and Flight Control systems.

DESIGN STANDARD ENGINEERS—Engineers or Designers, either Mechanical or Electronics, with a varied design background in the aircraft equipment field to develop standard design practices and help implant them in systems for Guidance, Weapons Director, Flight Control and associated instrumentation.

STANDARDS ANALYSTS—Analysts, Junior Designers, or Draftsmen with minimum of 3 or 4 years experience in aircraft or electronic equipment who are interested in Standards work. To assist the Design and Circuit Standards Engineers in the preparation of a design handbook and to layout Autonetics-designed Standard Detail parts drawings.

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Engineering Personnel
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WRITE:
A. S. Mittskus
Engineering Personnel
Dept. 991-9 SAE
P.O. Box AN
Bellflower, California

Applications Received

Continued

Northwest Section

Sherman W. Evans, Roy H. Johanson. Edward A. Rock, Floyd P. Wightman.

Oregon Section

Anthony F. Murty, Benedict P. Murty, Kenneth Willoughby.

Philadelphia Section

Victor E. Boccelli, Lewis J. DeVuono, Frank Webb Taylor.

Pittsburgh Section

James G. Berry, Jr., Joseph A. Juhas, F. Richardz, John M. Senko.

St. Louis Section

Bill L. Coffey, Samuel A. Gulotta.

Salt Lake Group

George R. Cravens, Don F. Woods.

San Diego Section

Jack S. Foster.

Southern California Section

Fred L. Boeke, Dale R. Burger, Victor B. Casner, Edmund F. Crotty, James F. Cullinane, John R. Feemster, Herbert W. Fenske, Jr., Robert G. Getrost, Albert M. Hetzel, Frank A. Hlavacek, C. T. Molloy, Cloyd Smith, Peter Thatcher, Benjamin T. Wakabayashi.

Southern New England Section

James V. Altieri, Jr., Erling J. Bligard, Manly E. Carroll, Jr., Thomas E Doherty, Walter D. France, Andre P. Sampou.

Syracuse Section

Alexander H. Dunbar.

Texas Section

David L. Kors.

Texas Gulf Coast Section

John B. Milwee.

Twin City Section

Derek D. Legg.

Washington Section

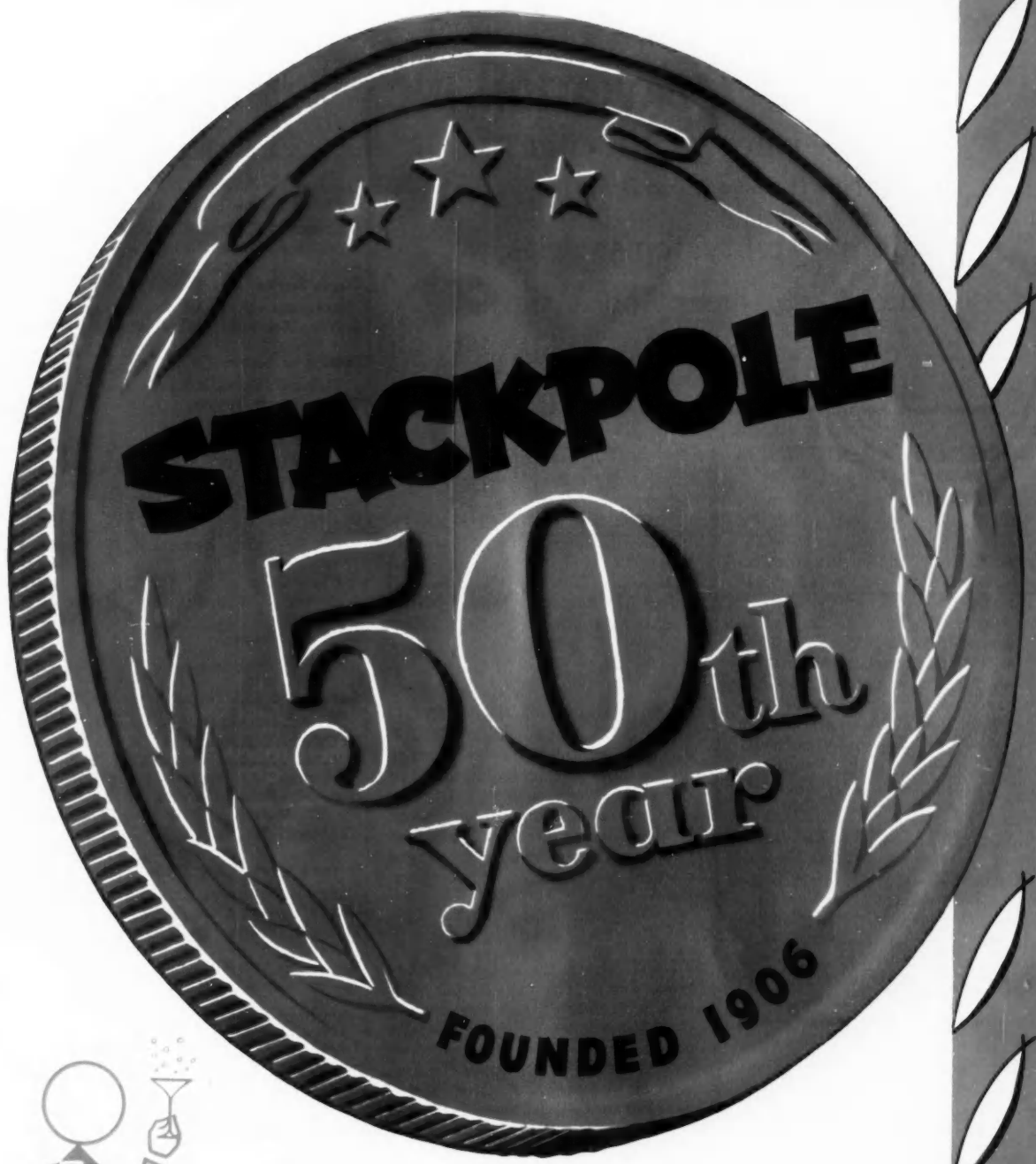
Leon O. Brooks, James E. Doran.

Outside of Section Territory

Manuel F. da Silva De Medeiros, Arthur J. Knippler, John W. F. Petch, Donald H. Roach.

Foreign

Egon Ardelius, Sweden; John A. Black, Australia; Leon Gattegno, Brazil; S. H. Grylls, England; Birger Holmer, Sweden; Ahmed A. Issa, Egypt; Jack T. Sydenstricker, Brazil.

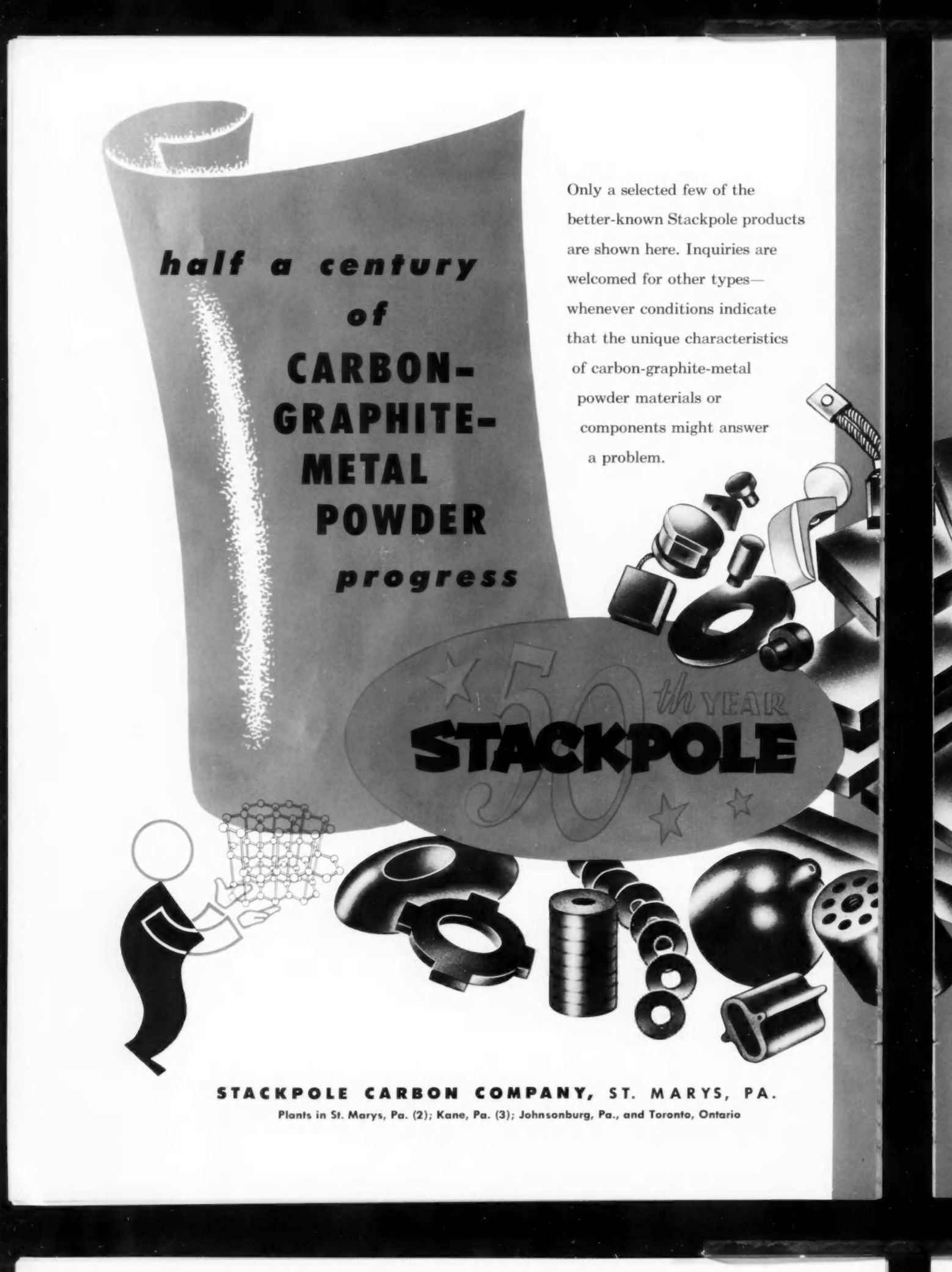


For fifty years, Stackpole engineering has centered around two of the most basic, oldest-known elements—carbon and graphite.

Singly, in combination or mixed with metal powders to form Stackpole materials and components, these age-old elements excel in meeting many of today's most exacting design, engineering and cost requirements.

Carbon and graphite offer a maximum of the desirable properties of both metallic and non-metallic materials—with a minimum of their disadvantages.

In many instances, they solve problems of friction, temperature, arcing, commutation, corrosion, voltage regulation, sealing and many others better, more economically than any other materials.



Only a selected few of the better-known Stackpole products are shown here. Inquiries are welcomed for other types—whenever conditions indicate that the unique characteristics of carbon-graphite-metal powder materials or components might answer a problem.

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

Plants in St. Marys, Pa. (2); Kane, Pa. (3); Johnsonburg, Pa., and Toronto, Ontario

STACKPOLE

BRUSHES

for all rotating electrical equipment

From the first practical high-altitude brushes to the latest 12-volt automotive and aviation types, Stackpole brushes cover the range of high-altitude and earth-surface requirements. Each type is specifically "tailored" to the equipment. Maximum commutation, trouble-free performance and long life are thus assured.

STACKPOLE

POWER TUBE ANODES

Non-warping, long-life types in practically any shape, size or composition for modern tubes.

STACKPOLE

VOLTAGE REGULATOR DISCS

Pressure-sensitive carbon disc stacks for critical resistance or voltage control uses.

STACKPOLE

CHEMICAL ANODES

Types and shapes for any cell, plain or treated for greatly minimized deterioration and maximum low-voltage operational economy and life.

STACKPOLE

CONTACTS

Silver-graphite • Silver-lead oxide • Silver-nickel • Silver-molybdenum • Silver-tungsten • Copper-graphite • Silver-copper-graphite • Gold-graphite • Silver-iron oxide . . . and many special grades, each specifically engineered to the application in which it is used.

STACKPOLE

RESISTANCE WELDING AND BRAZING TIPS

Famous Stackpole "F"-treated types last 4 to 5 times as long as conventional untreated tips.

STACKPOLE

SEAL RINGS

Types for sealing water, oil, chemicals and gases. New type Stackpole oil seals greatly reduce pitting and blistering.

STACKPOLE

ELECTRIC FURNACE HEATING ELEMENTS

For heavy-duty industrial applications to 6000°F. and above.

STACKPOLE

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Effective cathodic protection for buried pipe lines, storage tanks, structural footings, immersed structures, ship hulls and other marine installations.

STACKPOLE

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Carbon-graphite and copper-coated electrodes • Welding plates • Welding paste

STACKPOLE

MOLDS & DIES

Special types for ferrous and non-ferrous foundry work • Glass molding • rail bonding • powder metallurgy molding and many other similar uses.

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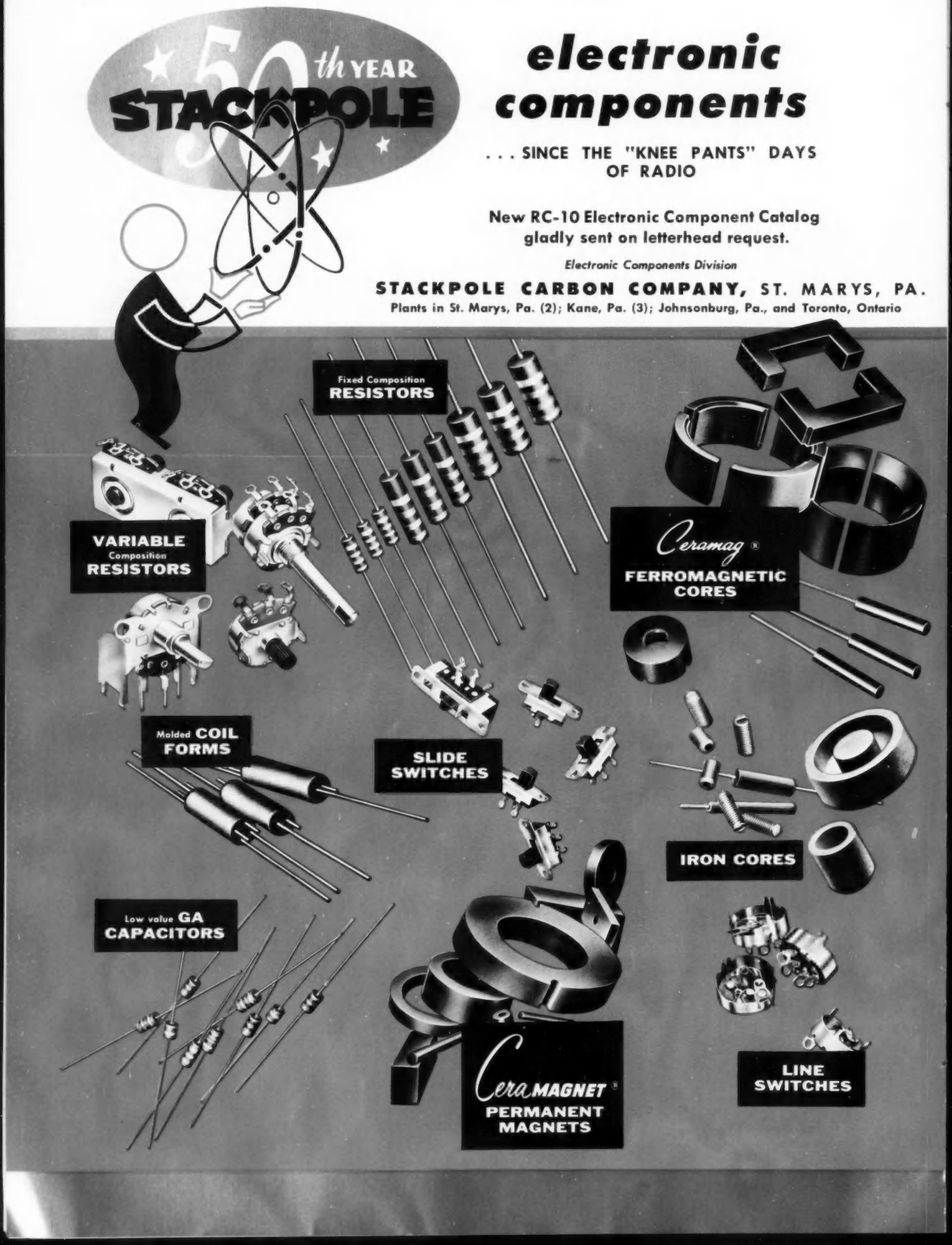
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electronic components
. . . SINCE THE "KNEE PANTS" DAYS OF RADIO
New RC-10 Electronic Component Catalog gladly sent on letterhead request.
Electronic Components Division
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Plants in St. Marys, Pa. (2); Kane, Pa. (3); Johnsonburg, Pa., and Toronto, Ontario
Fixed Composition RESISTORS
VARIABLE Composition RESISTORS
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Molded COIL FORMS
SLIDE SWITCHES
IRON CORES
Low value GA CAPACITORS
CeraMAGNET® PERMANENT MAGNETS
LINE SWITCHES

Chicago Transit Authority—the world's largest and most modern City Bus line —operates a fleet of over 3000 vehicles in the city and suburbs of Chicago, Illinois.

CTA Chicago Transit Authority Buses

set new standards of performance

In recent exhaustive comparison tests conducted by the Chicago Transit Authority —where brake maintenance is a ritual— Johns-Manville Brake Blocks gave 40% and 80% more mileage than that given by Brand B and Brand C. On new bus equipment operating under regular service conditions —these quality Johns-Manville Brake Blocks clearly demonstrated lower brake cost per mile, smoother stops, minimum shop and out-of-service time.

Johns-Manville 4-Star Brake Blocks can bring you these benefits, too. To match your requirements they are available in individual units, or combination sets of high, medium or low frictional characteristics. Regardless of the type of brake, or service conditions under which it must operate, there is a J-M Brake Block custom-engineered for the specific job it has to do.

Johns-Manville Field Engineers will help study your fleet operation and assist you in selecting the precise brake blocks which best match your particular operating conditions. There is no charge or obligation involved.

Write today for helpful information on any brake problem. Address: Johns-Manville, Box 60, New York 16, New York.

JM PRODUCTS

Johns-Manville *asbestos* **BRAKE LININGS**

Announcing...the First

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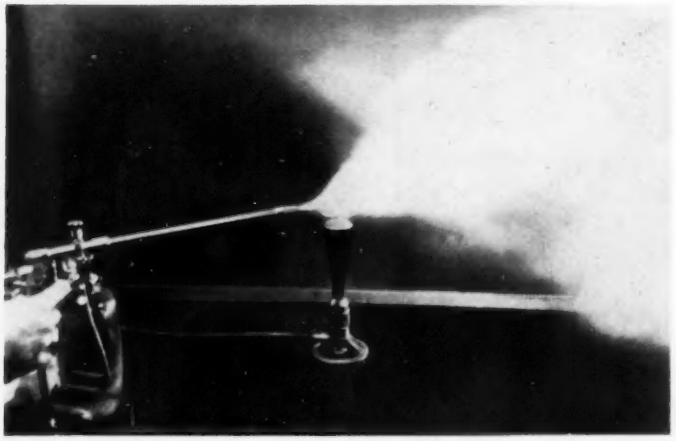
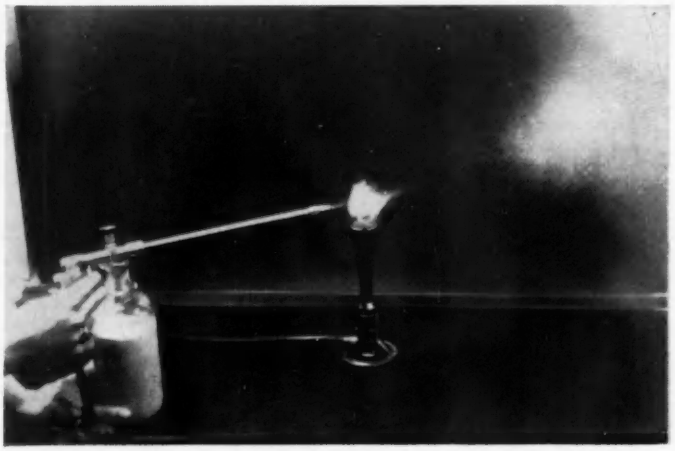
Flame tests prove its fire-snuffing ability



This photo shows the instant combustion taking place when a conventional hydraulic oil of mineral oil type is atomized over a Bunsen burner.



In this photo, Shell Irus Fluid 902 replaces the mineral oil. Note that there is no ignition.

SHELL IRUS FLUID 902

Oil-Base fire-resistant FLUID

SHELL IRUS FLUID 902

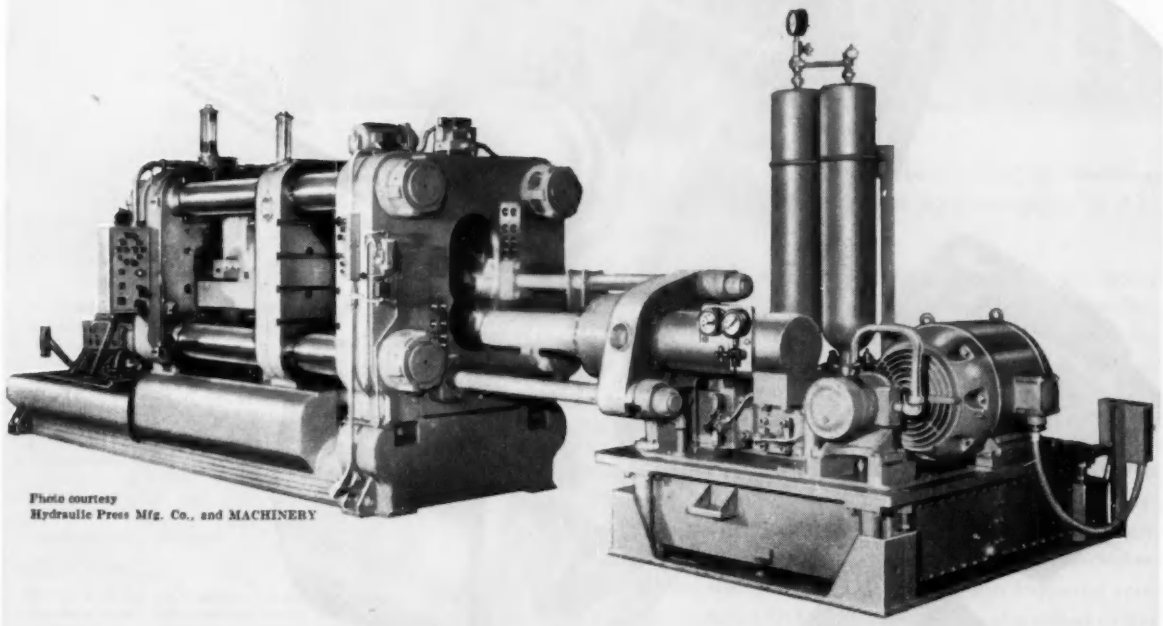


Photo courtesy
Hydraulic Press Mfg. Co., and MACHINERY

AFTER THREE YEARS of intensive research, field application and evaluation, Shell Irus Fluid 902 is now commercially available for use in industrial hydraulic systems. While its cost is far lower than other fire-resistant fluids, its performance is comparable.

No major modification of equipment is necessary. Shell Irus Fluid 902 is a special formulation containing no corrosive ingredients . . . no adverse effect on seals or fittings. It is a direct replacement for hydraulic oils now in service.

Noncorrosive, and nonrusting. Steel and copper panels immersed in Irus Fluid 902 for one week at 160°F have shown no significant signs of corrosion. Rusting has not been a problem in long-continued field tests.

This is an efficient fire-snuffing hydraulic fluid that can be widely used. Send coupon for details.

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SHELL

SHELL OIL COMPANY
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Please send me test data and information on Shell Irus Fluid 902.

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Company_____

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For Ball Bearings
THE TREND IS TO SKF®

Sleek, slim, powerful, quiet... *Mercury Outboards* are the ruler of speed and spray – "Master of the Waterways." Kiekhaefer Corporation, who makes them, was first to feature extensive use of anti-friction bearings in outboards. And Kiekhaefer is another concern that purchases single row, deep groove ball bearings from SKF.

It's a trend... brought about because those whose business is to buy bearings recognize the improvements SKF has achieved in ball bearings – improvements in quiet running, improvements in sealing, improvements in bearing life. Maybe *you* too should switch to SKF Ball Bearings.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

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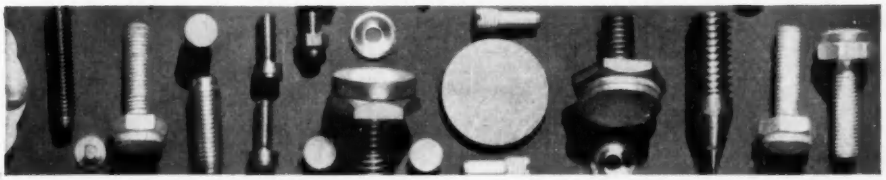
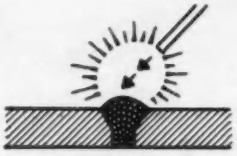
SKF

has them all

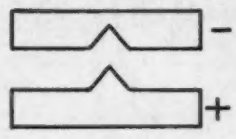
Ball Bearings · Cylindrical Roller Bearings
Spherical Roller Bearings · Tyson Tapered Roller Bearings

Dissimilar Metals in Electrical Contacts *Where and When to Use Them.*

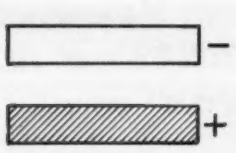




In electric welding, the arc carries metal from the welding rod and deposits it on the work.



Similarly, in d-c applications, the negative contact sometimes develops a pit, the migrating metal forming a cone on the positive side. Aggravated conditions cause contacts to stick.



The tendency to transfer may be minimized or eliminated by the use of dissimilar metals . . . a refractory metal on the negative side and a metal or alloy with which these metals do not readily weld on the positive side.

A copy of this book is yours for the asking. FANSTEEL METALLURGICAL CORPORATION NORTH CHICAGO, ILLINOIS, U. S. A.

While many contact problems have been solved by combining dissimilar contact materials, there is no easy, specific rule to dictate their selection.

In d-c circuits for instance, especially under inductive loads, metal transfer between contacts often occurs. This problem has been minimized, and in some cases eliminated completely, by employing two different metals: tungsten or molybdenum on the negative contact surface, and a metal to which refractory metals do not readily weld on the positive surface.

For example, Fasaloy* 12 paired with Grade CaW Tungsten has been a widely accepted combination for automotive, aviation, and industrial voltage regulators, telephone pole changers and other types of vibrators. This particular combination has not only solved the transfer problem, but also improved contact surface resistance and almost completely eliminated oxidation. Another example but under less severe conditions: Fasaloy 35 paired with Grade CaW Tungsten; and fine silver or one of the silver Fasaloys paired with molybdenum.

Where the rate of metal transfer is so pronounced that sticking or welding of the contact surfaces result . . . e.g., applications such as lamp loads or inductive peaks which involve heavy inrush currents . . . pairing Fastell* E with fine silver may solve the problem.

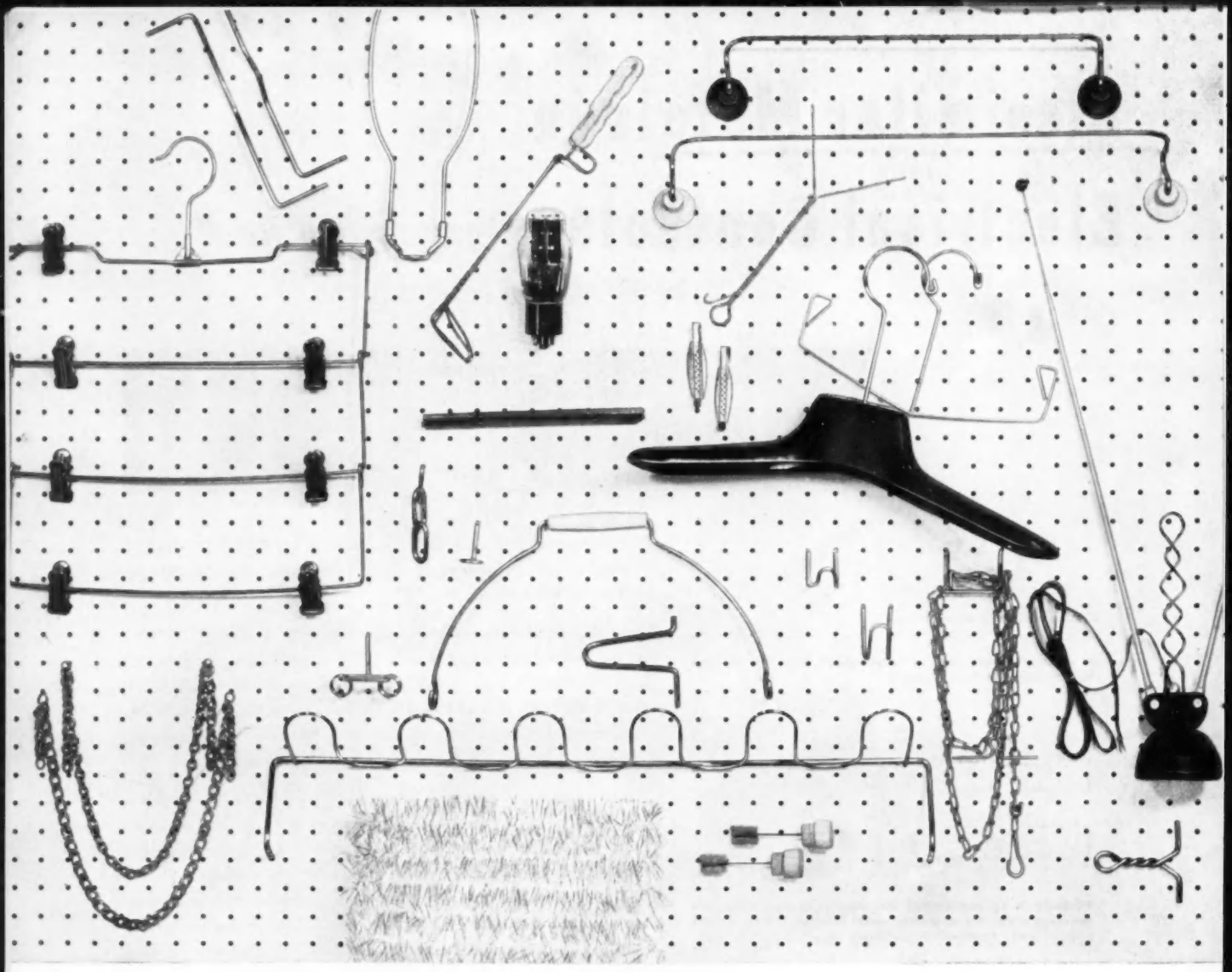
Along with minimizing or eliminating metal transfer, the right dissimilar metals can be paired to effect a low coefficient of friction. A combination of Fasaloy* 106 and fine silver has successfully reduced mechanical wear in contact operation where rotary, rubbing or wiping action is employed to keep contact surfaces clean.

Whatever the solution to your contact problem, Fansteel's experience in metallurgy and electrical contact engineering can specify it for you. Whatever the problem, it's always a good policy to CHECK WITH FANSTEEL.

F555

*Registered Trade Marks

FANSTEEL ELECTRICAL CONTACTS DEPENDABLE SINCE 1914



How these products were improved and costs lowered . . . with **NICKELPLY*, BRASSPLY*** and **COPPERPLY*** wire!

● National-Standard Nickelply, Brassply and Copperply is electro-jacketed steel wire—a new development offering important advantages to manufacturers and users of wire forms and components. Specifically . . . . .

The jacket metal, precisely concentric and to the required thickness, *is inseparably bonded to the steel wire.* The materials can be severely formed, twisted, swaged, welded, roll threaded or redrawn without fracturing the jacket metal or otherwise exposing the base metal. Thus these new materials can often replace solid nickel, brass or copper wire, or can eliminate the costly post-plating of steel wire forms . . . and with unmatched assurance of coating coverage! Advantages in strength, durability and economy are obvious.

Nickelply, Brassply and Copperply are now available commercially in diameters up to .340". Pertinent data on coating weights, strengths, finishes, base materials, corrosion resistance, etc., are given in Bulletin K-10. Why not send for it now and explore these new possibilities?

*Trade Mark National-Standard Company

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape

ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

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Industrial Wire Cloth

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WAGNER LITHO MACHINERY DIVISION • JERSEY CITY, N. J.
Special Machinery for Metal Decorating

WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

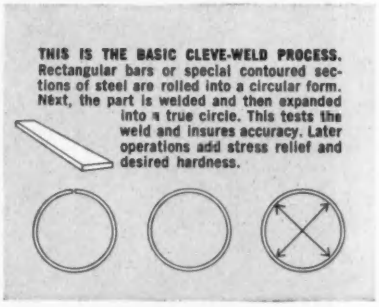
STRAIN

can halt your customers' payloads when rims don't give top performance. Stop complaints. Specify Cleve-Weld as your primary rim source.

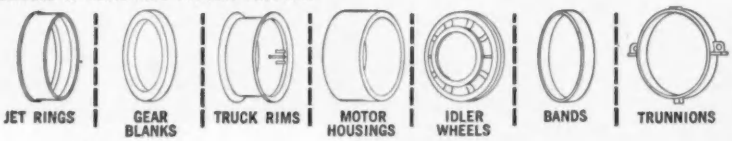
Cleve-weld rims are designed six ways better!

1. Rim thickened at strategic points... increases resistance to severe stresses.
2. Tapered beads on both sides of rim ...tire mates firmly with the rim.
3. 28° mounting bevel... enables rim to be mounted on all cast wheels.
4. Lightweight construction... means higher payloads for customers without loss of strength.
5. Tire rests on tapered bead seat... tire stays put when puncture occurs.
6. Designed for any brand or type of tire... flexibility ends tire replacement problems.

For 45 years Cleve-Weld has specialized in rolled and welded circular products... good reason why *you save when you specify Cleve-Weld as your primary source for all rolled and welded circular parts.* We'd like to talk it over. Write Circular Welded Products Sales Department at address below.


THIS IS THE BASIC CLEVE-WELD PROCESS. Rectangular bars or special contoured sections of steel are rolled into a circular form. Next, the part is welded and then expanded into a true circle. This tests the weld and insures accuracy. Later operations add stress relief and desired hardness.

EXAMPLES OF CLEVE-WELD PROCESS PRODUCTS



Another AMF Product
CLEVE-WELD PROCESS
RIMS · RINGS · WELDMENTS

CLEVELAND WELDING DIVISION
AMERICAN MACHINE & FOUNDRY COMPANY
Cleveland 11, Ohio

SEND THIS COUPON NOW

Cleveland Welding Division
American Machine & Foundry Company
West 117th Street and Berea Road
Cleveland 11, Ohio Dept. SAE-69

Please send me:

- ☐ Truck Rim Catalog
- ☐ Tractor Rim Catalog
- ☐ Brochure on Cleve-Weld Process

Name_____

Title_____

Attach to your company letterhead and mail

Performance of

Schrader valve construction principle . . . the same world's standard since the first automobiles.

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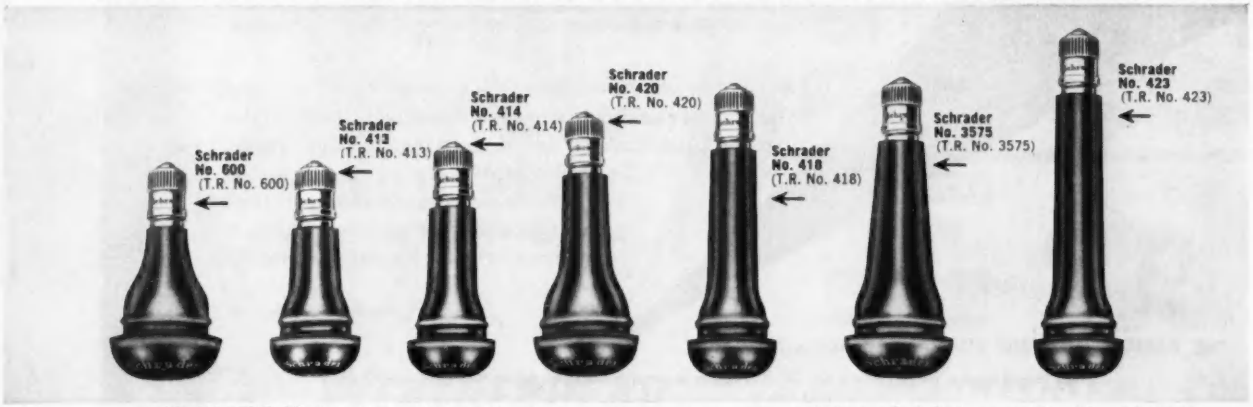
ESTABLISHED IN 1844

Schrader valves on new Tubeless-Equipped vehicles is the *best ever!*

With the giant swing to tubeless, Schrader Valves make maintenance and service simpler than ever, *regardless* of vehicle requirements. Schrader Valves become one with the rim . . . seal air as securely as the tire itself. The standard "long-core" principle engineered by Schrader half a century ago is unequalled for effective sealing. As the leading air products supplier to the industry, Schrader works with manufacturers to meet specific needs . . . keeps abreast with full lines . . . provides service, tools, parts and information wherever your product goes.

You can count on Schrader for latest tubeless tire valve design, developments, and above all . . . *performance!*

THESE ARE SOME OF THE NEWEST E-Z-E MOUNT TUBELESS VALVES AND THE LATEST VALVE PRACTICE


Schrader No. 600 (T.R. No. 600)
Schrader No. 413 (T.R. No. 413)
Schrader No. 414 (T.R. No. 414)
Schrader No. 420 (T.R. No. 420)
Schrader No. 418 (T.R. No. 418)
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FIRST NAME IN TIRE VALVES

FOR ORIGINAL EQUIPMENT AND REPLACEMENT

ONE OF THE GARLOCK 2,000

Springless Klozure (cutaway) shown on a BALL BUSHING (linear ball bearing) manufactured by Thomson Industries, Inc., Manhasset, New York.

First Choice

FOR LINEAR MOTION, TOO!

Klozure* Oil Seals Protecting bearings from dust and other contamination is as important in linear applications as it is in rotary bearing applications. That's why Thomson Industries, selected Garlock Klozure Oil Seals Model 71-A for their linear ball bearing. Thomson found that the unique design of the 71-A and its synthetic rubber sealing element made it ideal for their limited space, low pressure, grease retaining application.

Let us show you how one of "the Garlock 2,000" can help you . . . you can choose from two thousand different styles of packings, gaskets, and seals to meet all your needs. It's the only *complete* line . . . it's one reason you get *unbiased* recommendations from your Garlock representative. Call him today or write for Klozure Catalog 10.

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THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.*

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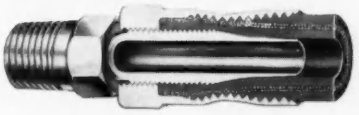
First in components for HYDRAULIC SYSTEMS

Look at anything . . . anywhere in the world . . . in hydraulics, diesel power or machine tool applications . . . equipment for instrumentation, oil drilling, mining, road building, petro-chemicals or even atomic power . . . chances are the vital air and fluid lifelines are secured with WEATHERHEAD.

Reusable Hose Ends

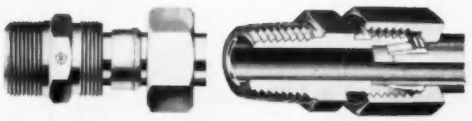


Bulk Hose

Hose Assemblies

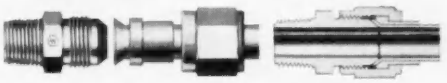
Crimped | Swaged

ERMETO®



SAE 37° FLARE

3-PIECE



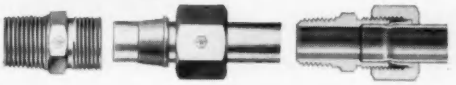
2-PIECE

SAE 45° FLARE

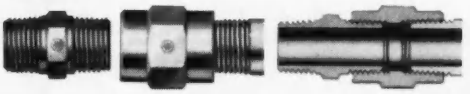
INVERTED FLARE

COMPRESSION

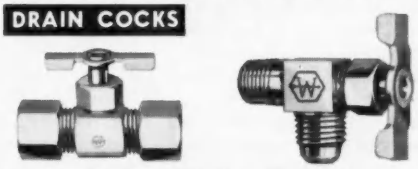
SELFALIGN®



PIPE



DRAIN COCKS



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FIRST IN HYDRAULIC CONNECTIONS

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Dept. AD-9, 128 West Washington Blvd., Fort Wayne, Indiana

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WEATHERHEAD

The only single-source hydraulic hose and fitting line.

Available coast-to-coast through Weatherhead distributors.

New Strength and Safety for the "Second Greatest Show on Earth"

When P. T. Barnum rode the fabulous cog railway up New Hampshire's 6288-ft Mount Washington, he dubbed it "the second greatest show on earth." Every summer, some 35,000 riders tend to agree.

The locomotives chuffing stubbornly to the summit look like museum pieces, and the right of way is somehow reminiscent of a roller coaster at an amusement park. Yet from the time the line started nearly ninety years ago no passenger has lost his life.

The line jealously guards this safety record, and this summer is placing in service a spanking new coach, its first all-metal one. With emphasis on lightweight construction, the car will have an underframe built of Mayari R high-strength low-alloy steel. With a yield point a good deal higher than that of carbon structural steel, the Mayari R frame members can be much lighter and still provide all the strength that will ever be needed.

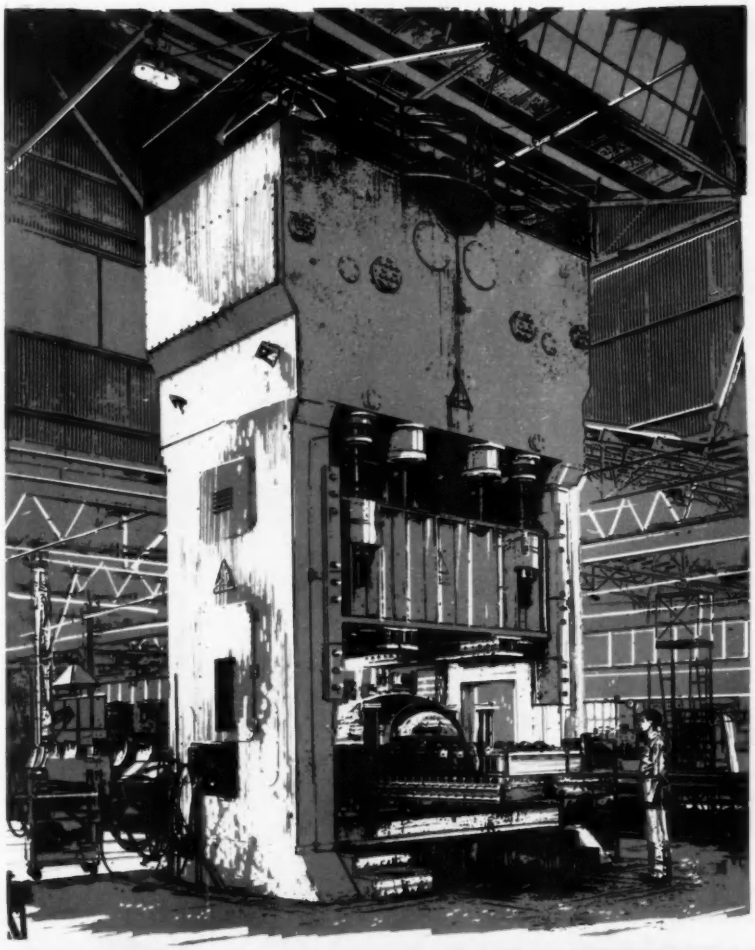
This is an off-the-beaten-track example of Mayari R's value in railway, automotive, structural and general manufacturing use. Mayari R is unusually strong, is unusually paint-adherent, and unusually resistant to corrosion and abrasion. It can be welded and worked as readily as carbon steel. Catalog 353 explains it in detail, and shows dozens of interesting applications. You can get a copy through our nearest sales office.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Mayari R . . . High-Strength, Corrosion-Resisting Steel



750-TON CLEARING PRESS—
PART OF

ROHR'S MULTI-MILLION DOLLAR TOOL KIT

This mighty press is one of the largest of its kind in the world. With its precision fingers it is particularly adapted to the delicate function of forming compound-contour skin sections for aircraft assemblies of many kinds.

Today, with this and hundreds of other heavy manufacturing machines, Rohr produces over 30,000 different parts for aircraft of all types. This is, of course, in addition to Rohr's being recognized as the world's largest producer of ready-to-install power packages for airplanes.

For design and engineering know-how, for full production facilities look to Rohr to build more into the aircraft parts you need.

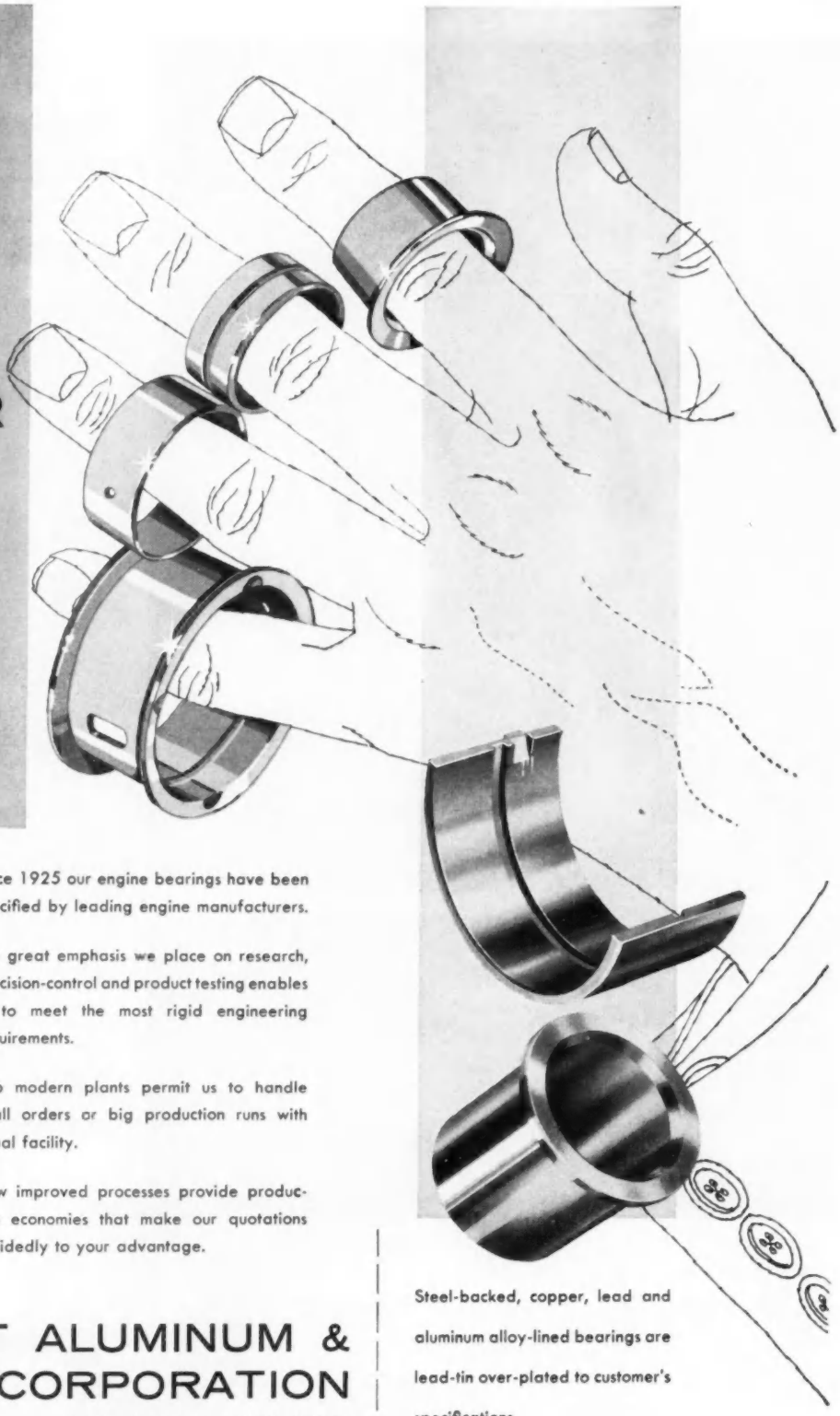
In addition to the Lockheed C-130 Hercules shown here, Rohr builds power packages for many other leading commercial and military planes which have made Rohr famous as the

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POW-R-PAX FOR AIRPLANES

ROHR
AIRCRAFT CORPORATION

PLANTS IN CHULA VISTA AND RIVERSIDE, CALIFORNIA; WINDER, GEORGIA—SOON TO BE IN AUBURN, WASHINGTON

4 THINGS TO REMEMBER THE NEXT TIME YOU BUY ENGINE BEARINGS



1. Since 1925 our engine bearings have been specified by leading engine manufacturers.
2. The great emphasis we place on research, precision-control and product testing enables us to meet the most rigid engineering requirements.
3. Two modern plants permit us to handle small orders or big production runs with equal facility.
4. New improved processes provide production economies that make our quotations decidedly to your advantage.

Steel-backed, copper, lead and aluminum alloy-lined bearings are lead-tin over-plated to customer's specifications.

DETROIT ALUMINUM & BRASS CORPORATION

DETROIT 11, MICHIGAN

Plants at Detroit, Michigan and Bellefontaine, Ohio

CUT COSTS FROM BARREL TO BEARINGS...

Change lubrication methods from

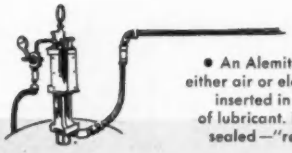
Backward to Forward!

ALEMITE "POWER HOUSE" BARREL PUMP

saves 95 man-hours for every 400-lb. drum of lubricant you use

Lubricating hundreds of bearings by slow, outgrown hand methods is a costly waste of time and money. A modern Alemite "Power House" Barrel Pump does the job much faster—at less cost. You save 95 man-hours for every 400-lb. drum of lubricant used. And because a completely sealed Alemite Barrel Pump system gives cleaner, more efficient lubrication, you make big savings right down the line. Savings in less down-time, and lower maintenance costs . . . in greater efficiency and output.

Air-powered Alemite Barrel Pumps fit directly into either a 400- or 120-lb. drum, send lubricant wherever it is needed anywhere in the plant. Or drum and pump can be placed on a dolly to go right to the machines. You get the big advantage of a completely sealed system. Lubricant reaches bearings "refinery clean"—no mess or waste.



• An Alemite Barrel Pump, either air or electric powered, is inserted in a fresh drum of lubricant. Lubricant is still sealed—"refinery fresh."

• Now the Barrel Pump supplies lubricant, through pipe, anywhere in the plant. Operator simply carries a hose and control valve to outlet, hooks it in, applies lubricant.

• Where piping of lubricant is not practical, power lubrication can be brought right to the machine by simply mounting drum and pump on a dolly.

FREE! New Booklet:
"5 Plans for Better Lubrication"

Alemite, Dept. JJ-96, 1850 Diversey Parkway
Chicago 14, Illinois

Please send me my FREE copy of "5 Plans for Better Lubrication."

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ALEMITE

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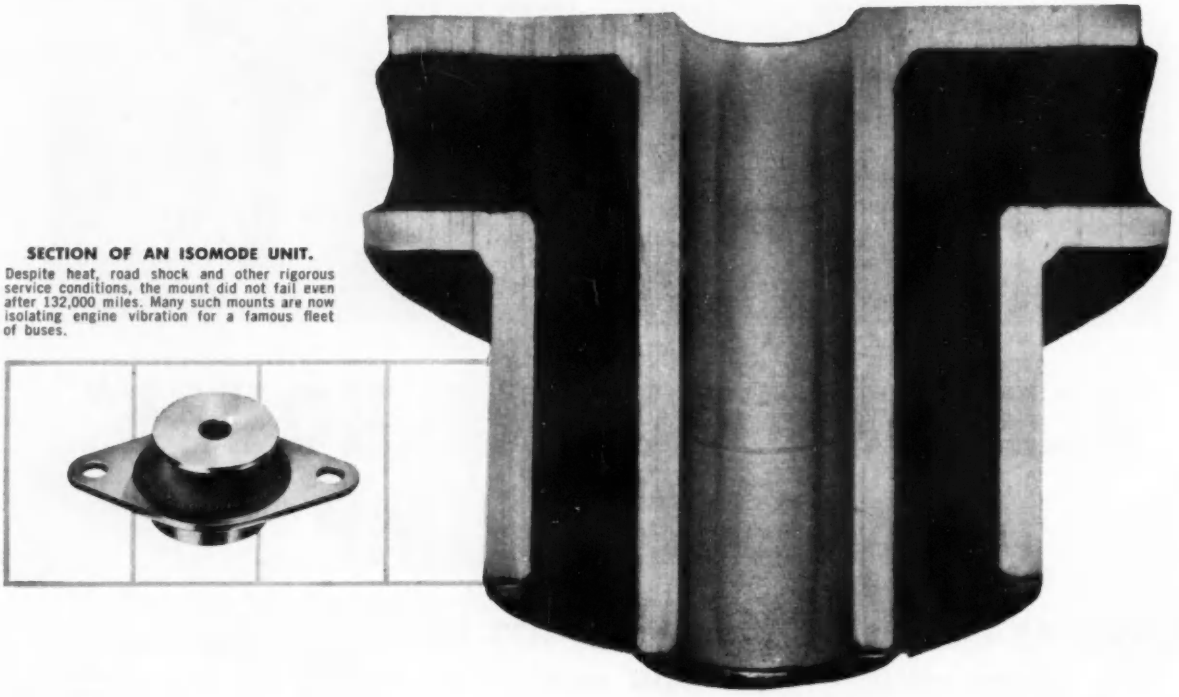
BARREL PUMPS

Products of STEWART-WARNER CORPORATION

STEWART SW WARNER

MB engine mount proves good for 132000 miles!



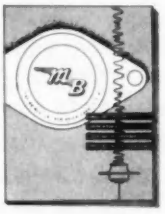
SECTION OF AN ISOMODE UNIT.
Despite heat, road shock and other rigorous service conditions, the mount did not fail even after 132,000 miles. Many such mounts are now isolating engine vibration for a famous fleet of buses.

Above you see a section of an Isomode® type 5 vibration isolator after 132,000 miles of bus service. Breaking an endurance record, the mount could easily have gone to 150,000 miles.

It takes an extremely *rugged* mount to survive the countless road shocks, engine vibration, and stresses of so much travel . . . and still be good for more. As for *performance,* these mounts were originally specified for the well known buses they're in because of *outstanding* vibration isolation.

It's all due to their design . . . the original "Isomode" principle developed by MB over 10 years ago. Cores are in *balanced* compression and shear . . . for the same spring rate in all planes. This controls all modes of motion with equal efficiency, permits mounting at any angle. Note, too, that this design is self-snubbing, preventing excessive motion and damage.

These special-performance, type 5 Isomode units are available as standard parts, with or without mounting ears, for loads of 50 to 2500 pounds. They can also be adapted to your specific needs.



Satisfying difficult vibration control requirements has been MB's business for 17 years. You're welcome to draw on this experience.

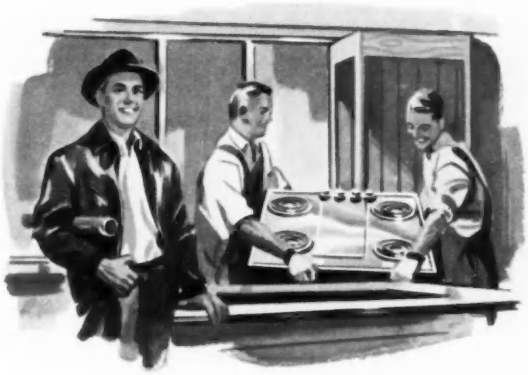
Bulletin 616 gives useful data. Send for your copy.

manufacturing company
A Division of Textron Inc.
1060 State Street
New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO ISOLATE VIBRATION . . . TO EXCITE IT . . . TO MEASURE IT.

in the home everybody benefits from

STAINLESS STEEL



THE ARCHITECT designs Stainless Steel into windows, kitchens, work surfaces, ovens and other important places because he knows there is nothing like Stainless for clean, lasting beauty.

THE BUILDER has had long experience with Stainless Steel. It's easy to install, does not chip or peel, and its beautiful finish presents no problem on matching or replacement.

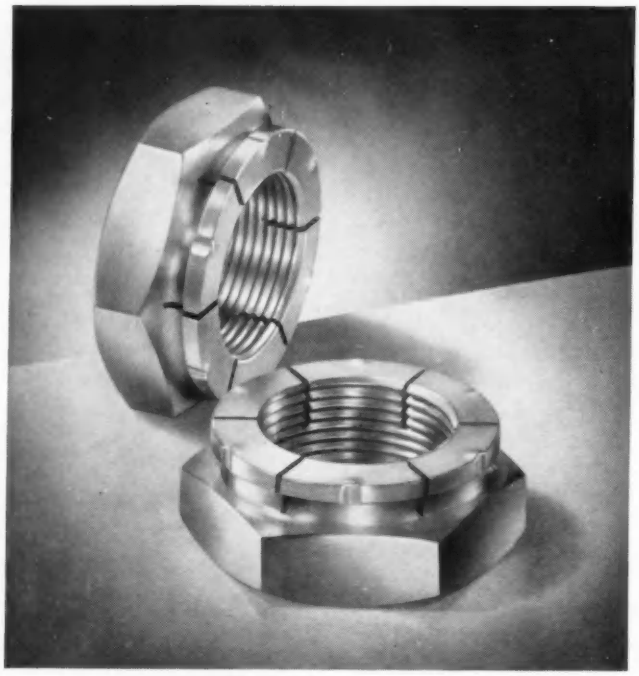
the owner likes living with Stainless Steel. It's always gleaming and beautiful, cleans with a wipe, and lasts forever. And, to complement her kitchen she loves to own those shiny pots, pans, tableware, and appliances, all made of Stainless Steel.

McLOUTH STAINLESS STEEL

FOR THE PRODUCT YOU MAKE TODAY AND THE PRODUCT YOU PLAN FOR TOMORROW SPECIFY McLOUTH HIGH QUALITY SHEET AND STRIP STAINLESS STEEL

McLOUTH STEEL CORPORATION DETROIT, MICHIGAN • MANUFACTURERS OF STAINLESS AND CARBON STEELS

Flexloc thin nuts save space, weight and production time



Self-locking nuts are 30% lower and lighter; speed up assembly with hand or power tools

Self-locking FLEXLOC thin nuts are 30% lower than regular height locknuts of the same nominal diameter. They fit into spaces where regular height locknuts will not go. You can design lighter, more compact units with them.

Where you must reduce weight in a completed assembly, you can save by using shorter bolts with these lighter nuts. And you save production time. The length of engagement of mating threads is shorter: fewer revolutions of hand wrenches or power nut runners are needed to seat them.

FLEXLOC nuts are of 1-piece, all-metal construction. You can use a FLEXLOC fully seated as a locknut or at any point along a bolt as a stop nut. Once the threads in the resilient locking section are fully engaged, the FLEXLOC grips the mating threads with uniform locking torque wherever wrenching stops. Since there are no nonmetallic inserts to come out or deteriorate, the locking life of a FLEXLOC is virtually unlimited.

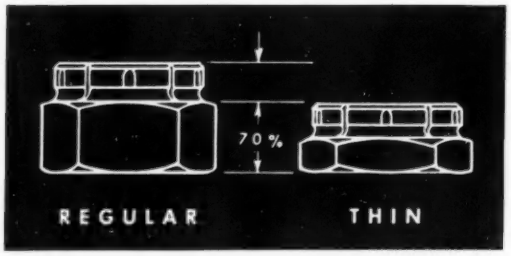
Your authorized industrial distributor stocks FLEXLOC nuts in a variety of sizes, materials and finishes. Consult him for details. Or write us for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 55, Pa.

SPECIFICATIONS
FLEXLOC THIN NUTS

NATIONAL COARSE THREAD—U.S.S

SIZE	A INCHES	H INCHES	WIDTH ACROSS CORNERS	WEIGHT PER 1000 NUTS
6-32	.312	.125	.361	1.8
8-32	.344	.172	.397	2.8
10-24	.375	.172	.433	3.3
¼-20	.438	.203	.505	5.4
5/16-18	.563	.250	.649	11.6
3/8-16	.625	.265	.722	14.9
7/16-14	.750	.312	.866	24.9
½-13	.813	.312	.938	28.4
9/16-12	.875	.359	1.010	36.1
5/8-11	1.000	.391	1.155	54.1
¾-10	1.125	.406	1.299	69.2
7/8-9	1.312	.469	1.516	107.5
1-8	1.500	.563	1.732	171.6
NATIONAL FINE THREAD—S.A.E.				
6-40	.312	.125	.361	1.8
8-36	.344	.172	.397	2.8
10-32	.375	.172	.433	3.3
¼-28	.438	.203	.505	5.4
5/16-24	.500	.250	.577	8.7
3/8-24	.563	.266	.649	11.5
7/16-20	.625	.312	.722	14.9
½-20	.750	.312	.866	21.7
9/16-18	.875	.359	1.010	36.2
5/8-18	.938	.391	1.082	42.4
¾-16	1.063	.406	1.227	54.5
7/8-14	1.250	.469	1.443	84.6
1-14	1.438	.563	1.660	136.3
1 1/8-12*	1.625	.625	1.876	193.5
1 ¼-12*	1.813	.750	2.093	296.0
1 3/8-12*	2.000	.812	2.309	389.0
1 ½-12*	2.187	.875	2.526	498.0

*Steel only (plain or cadmium plated) in stock sizes.



FLEXLOC thin nuts are 30% lower than regular height locknuts. There is a corresponding saving in weight. In sizes through 5/16 in., thin FLEXLOCS meet tensile strength requirements for regular height locknuts. FLEXLOC nuts can be made in the thin type because every thread, even those in the locking section, carries its full share of the load. There are no nonmetallic inserts to waste head space or weaken the structure of the nut.

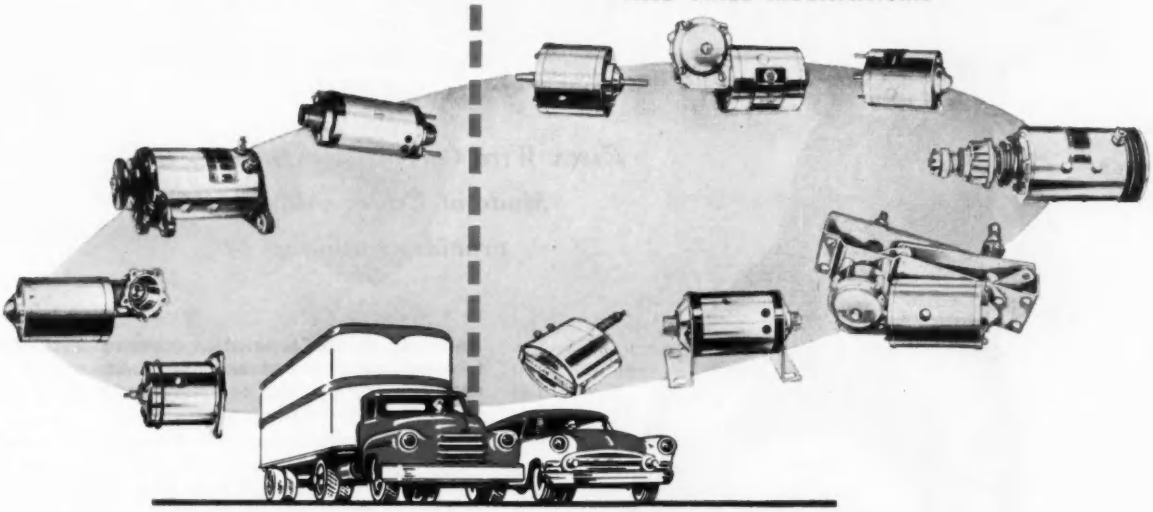
Standard FLEXLOC self-locking thin nuts are available in plain or cadmium plated alloy steel, for use in temperatures to 550°F; in plain or silver plated corrosion resisting steel, for temperatures to 750°F; and in brass and aluminum, for temperatures to 250°F.

STANDARD PRESSED STEEL CO.
FLEXLOC LOCKNUT DIVISION SPS
JENKINTOWN PENNSYLVANIA

A large versatile family of
AMERICAN BOSCH
SMALL ELECTRIC MOTORS
for automotive services

American Bosch offers a variety of small, high torque electric motors, precision engineered for quiet power and sturdy dependability. If you have one or a number of small motor requirements in your designs, put the problem up to American Bosch, Springfield 7, Mass. A Division of American Bosch Arma Corporation.

TO POWER
WINDSHIELD WIPERS • VENTILATORS
WINDOWS • SEATS • TOPS • HOODS
STARTERS • HEATERS • TRANSMISSIONS
AND AXLE MECHANISMS



AMERICAN BOSCH

Essex Wire Corporation Battery Cable—
Made of Kaiser Aluminum—
provides saving of 14%

American Motor Corporation engineers, alert for ways to reduce costs without reducing quality and performance, have standardized on aluminum battery cable for Rambler, Nash and Hudson cars.

Aluminum cable, supplied by Essex Wire Corporation, Detroit, weighs only half as much as copper and *provided an initial cost reduction of over 14%*. Aluminum's light weight also makes possible additional savings in shipping costs and contributes to over-all weight reduction.

This all new aluminum battery cable was engineered.

and designed to supply equal current carrying capacity and lower resistance than equivalent copper cable.

This is one more example of how versatile aluminum . . . combined with sound engineering . . . can improve quality and reduce costs in the automotive industry.

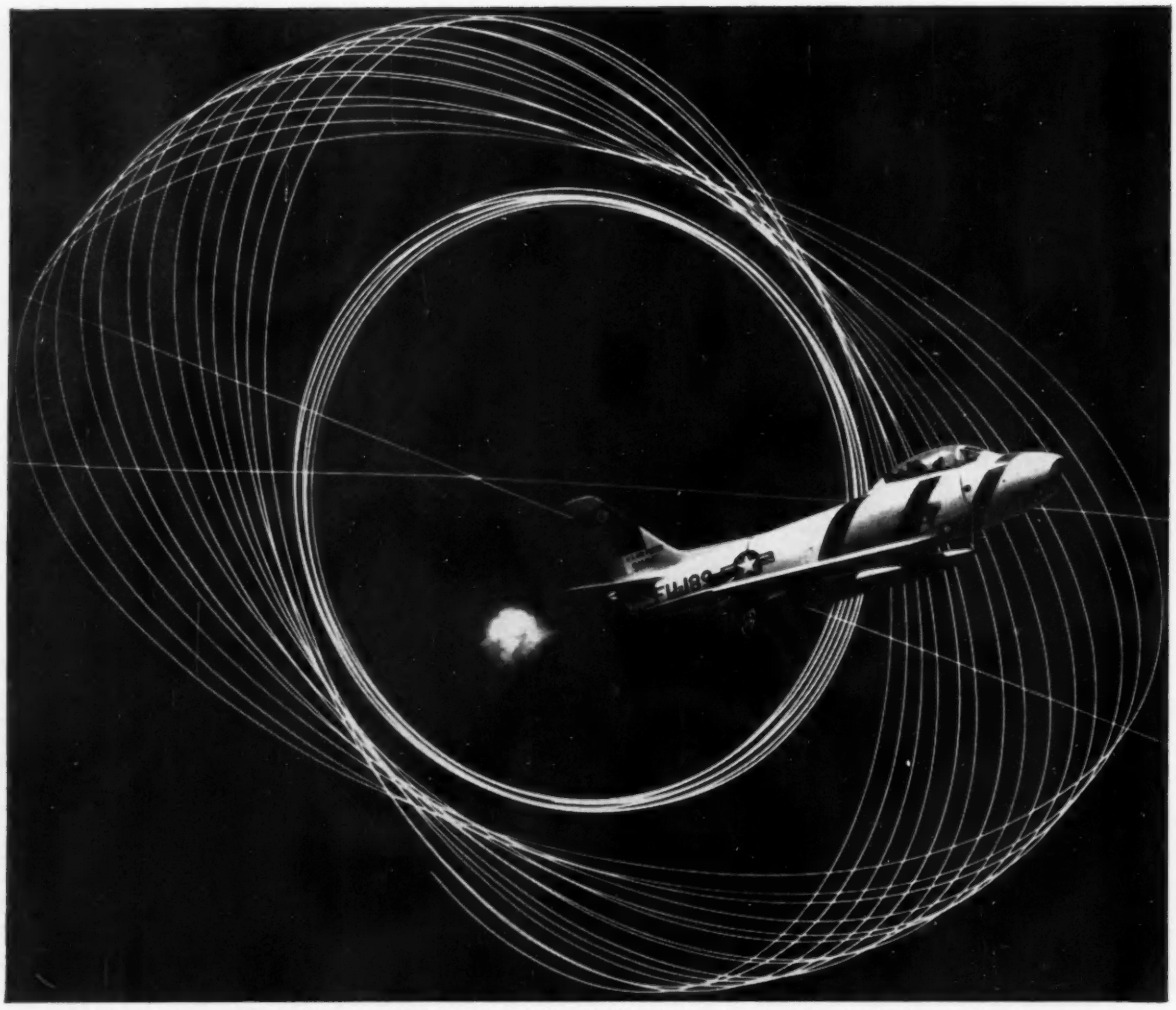
Make our automotive development engineers your *"idea partners."* Combine your knowledge of your product with our experience with aluminum to help you obtain maximum improvements and savings.

Also, if you need assistance in finishing, welding, forging, roll-forming, extrusions, stampings, castings—or desire engineering service or fabricating counsel—our development engineers will gladly provide it.

Call our *Automotive Development Division,* TRinity 3-8000, Kaiser Aluminum & Chemical Sales, Inc., 1414 Fisher Bldg., Detroit 2, Michigan. *General Sales Office,* Palmolive Bldg., Chicago 11, Ill.; *Executive Office,* Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.



A jet fitted with AUTONETICS Flight Test equipment shoots smoke puffs from wingtip pods to create aerial markers for checking control systems' accuracy.

Autonetics' "flying laboratories" spearhead electro-mechanical breakthroughs

Before major battles can be won in the development of automatic control systems, much scientific reconnaissance must take place high in the air.

AUTONETICS' Flight Test Section is uniquely equipped to do this job—in all phases of systems development, whether the projects are fresh from the laboratory or in final performance evaluation. Using probably the largest fleet of test vehicles in the industry, Flight Test experts extend AUTONETICS' engineering into the elements . . . at altitudes, speeds and extreme conditions that are dress rehearsals of possible future situations.

Keeping accurate, automatic records of systems performance during these live tests is another great challenge. Since the best available recording equipment is usually less accurate than the system being tested, extraordinary custom-engineering is required. For example, normal instrumentation recording setups usually contain a percentage of error, and the data on these systems must be gathered to such accuracy that new and specialized techniques and equipment are necessary. These electronic refinements are designed and built right on the spot at AUTONETICS' Flight Test, assuring hitherto unknown degrees of precision.

In 10 years AUTONETICS has achieved full capability in research, development, design, manufacture and test of complete systems in information processing, inertial navigation, flight controls, weapons director controls, computers and other special products.

For more detailed information, or for employment in any one of these fields, please write: AUTONETICS, Dept. SAE-N4, 12214 Lakewood Blvd., Downey, California.

Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC.

AUTOMATIC CONTROLS MAN HAS NEVER BUILT BEFORE

For more customer satisfaction—equip your trucks with the world's most preferred air brakes—BENDIX-WESTINGHOUSE!

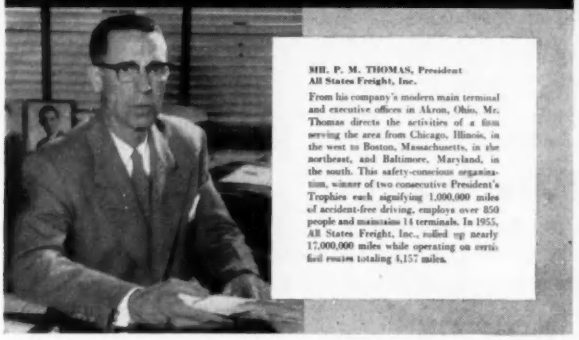
"In our 25 years in business

We've bought 1,455 trucks

AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES



MR. P. M. THOMAS, President
All States Freight, Inc.

From his company's modern main terminal and executive offices in Akron, Ohio, Mr. Thomas directs the activities of a firm serving the area from Chicago, Illinois, in the west to Boston, Massachusetts, in the northeast, and Baltimore, Maryland, in the south. This safety-conscious organization, winner of two consecutive President's Trophies each signifying 1,000,000 miles of accident-free driving, employs over 850 people and maintains 14 terminals. In 1955, All States Freight, Inc., rolled up nearly 17,000,000 miles while operating on certificated routes totaling 4,157 miles.

"We've bought 2,000 trucks

AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

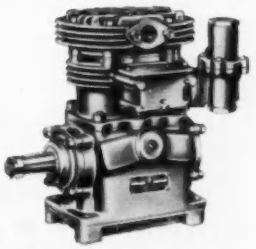
THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

MR. STANLEY L. WASIE, President
Merchants Motor Freight, Inc.

"Don't mark it rush, mark it Merchants—synonym for speed, dependability, and complete transportation satisfaction" is a slogan that Mr. Wasie and all 750 employees of this big St. Paul, Minnesota, trucking firm strive to make a living symbol to all shippers. Last year Merchants' rigs rolled up a total of nearly 14,000,000 miles while travelling routes of 5,497 miles. Merchants Motor Freight, Inc., maintains thirteen terminals located in the states of Minnesota, Illinois, Iowa, Missouri, Nebraska, Colorado, Michigan, and Ohio.

For twenty-five years Bendix-Westinghouse Air Brakes have been the first choice of truck manufacturers and truck operators everywhere, consistently outselling all other makes of air brakes combined. In fact, recognition of the greater safety, economy and dependability of Bendix-Westinghouse Air Brakes by truck buyers has resulted in their factory installation on an ever-increasing number of truck models of all sizes.

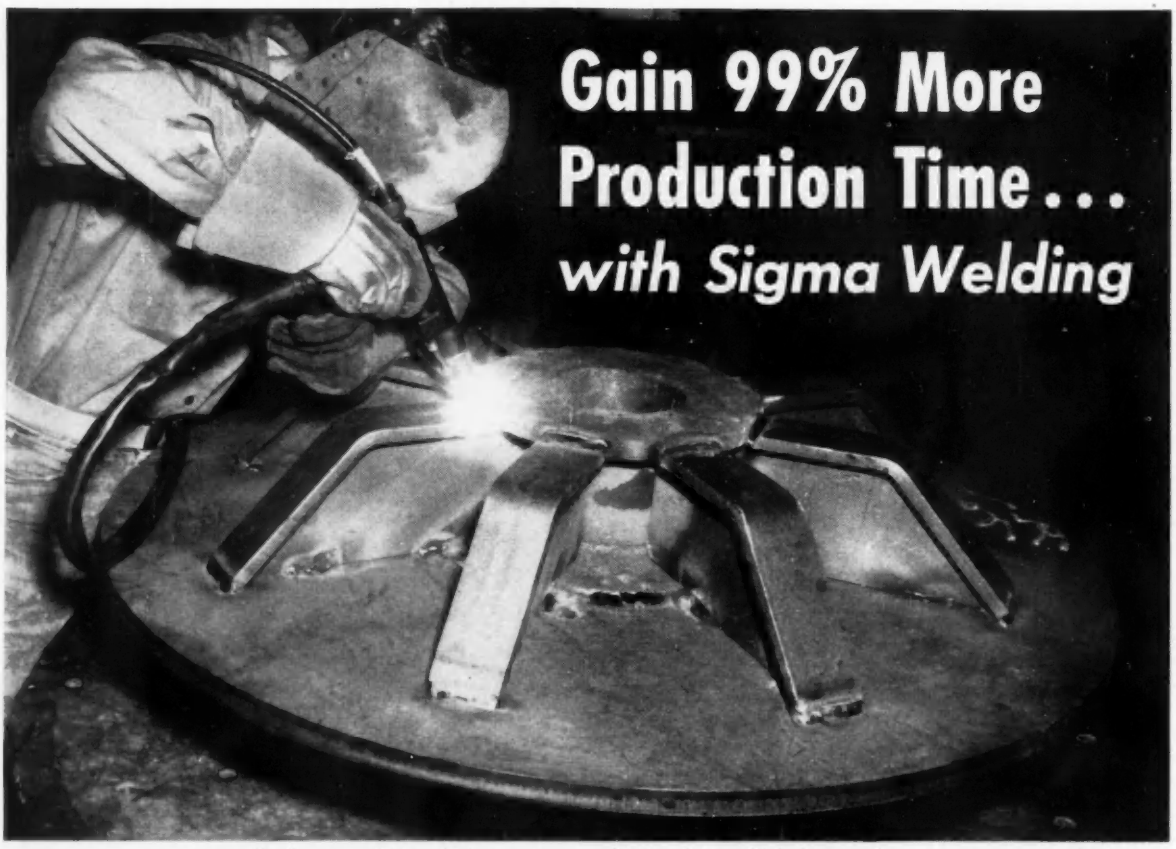
Chances are good that your trucks, too, offer the many advantages of these powerful brakes. If not, we suggest that you take advantage of the proven preference and superiority of Bendix-Westinghouse Air Brakes by offering them as factory-installed equipment. It's one sure and easy way to add more sales-appeal to your vehicles!



Over 1,500,000 compressors, produced over a twenty-five-year span, stand behind the TU-FLO 400. Many advanced features guarantee performance no other compressor can equal.

Bendix-Westinghouse BENDIX-WESTINGHOUSE AIR BRAKES® **AIR BRAKES**

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • General Offices and Factory—Elyria, Ohio • Branches—Berkeley, Calif. and Oklahoma City, Okla.



Steel gussets, ⅝-in. thick are sigma welded to ⅞-in. thick drum ends at an average speed of 15-in. per minute.

This welding operator doesn't have to bother with fluxes—and he doesn't lose valuable time changing burned down electrodes. In fact, by using sigma welding in this operation, the Cardwell Manufacturing Company, Wichita, Kansas has increased welding speed and almost doubled arc time. The results—a better product, faster, and at less cost.

AUTOMATIC WIRE FEED

Sigma welding uses a welding wire, supplied from a convenient sized coil, as a consumable electrode. In this case it is stainless steel wire which is fed automatically, and at a predetermined rate, into the welding arc. This ups welding speeds and simplifies work.

NO FLUX

The arc is maintained in a shield of argon gas which envelopes the area between welding wire and work piece. Inert gas protection assures highest weld quality, and further simplifies welding operations.

Sigma welding is available in both manual and mechanized setups. Call or write your local LINDE representative for free illustrated literature, and find out how you can gain new production speed and unit quality with a sigma welding installation.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

This outstanding Hunter Douglas pre-painted Aluminum Strip excels 5 ways!

When specifying pre-painted stock, most users know that compromises are frequently imperative . . . to gain the utmost in one particular quality other qualities are necessarily subordinated. Yet this two coat, baked enamel Hunter Douglas Aluminum Pre-Painted Strip shows *high scores on every desirable characteristic!*

REMARKABLE FORMABILITY—High elasticity with strong adhesion permits severe bending without cracking of painted surface. On press operations it blanks cleanly and sharply, resists flaking and chipping. Successfully embosses, roll forms and draws *without scratching due to exceptional hardness of surface!*

EXCELLENT WEATHER RESISTANCE AND EXTERIOR DURABILITY—Comparable to best quality of baked-enamel automotive finishes. Unusually color-fast in sunlight.

MAXIMUM HUMIDITY RESISTANCE—Successfully withstands 500 hour, 100° F., 100% humidity without lifting, blistering or film failure.

MAXIMUM SALT SPRAY RESISTANCE—Successfully withstands 500 hour, 95° F., 20% salt spray.

SPARKLING BEAUTY—Two coat finish with each coat individually baked builds up solid opacity and unmatched depth of lustre and tone. Available in a wide range of colors matching or contrasting with your other décor.

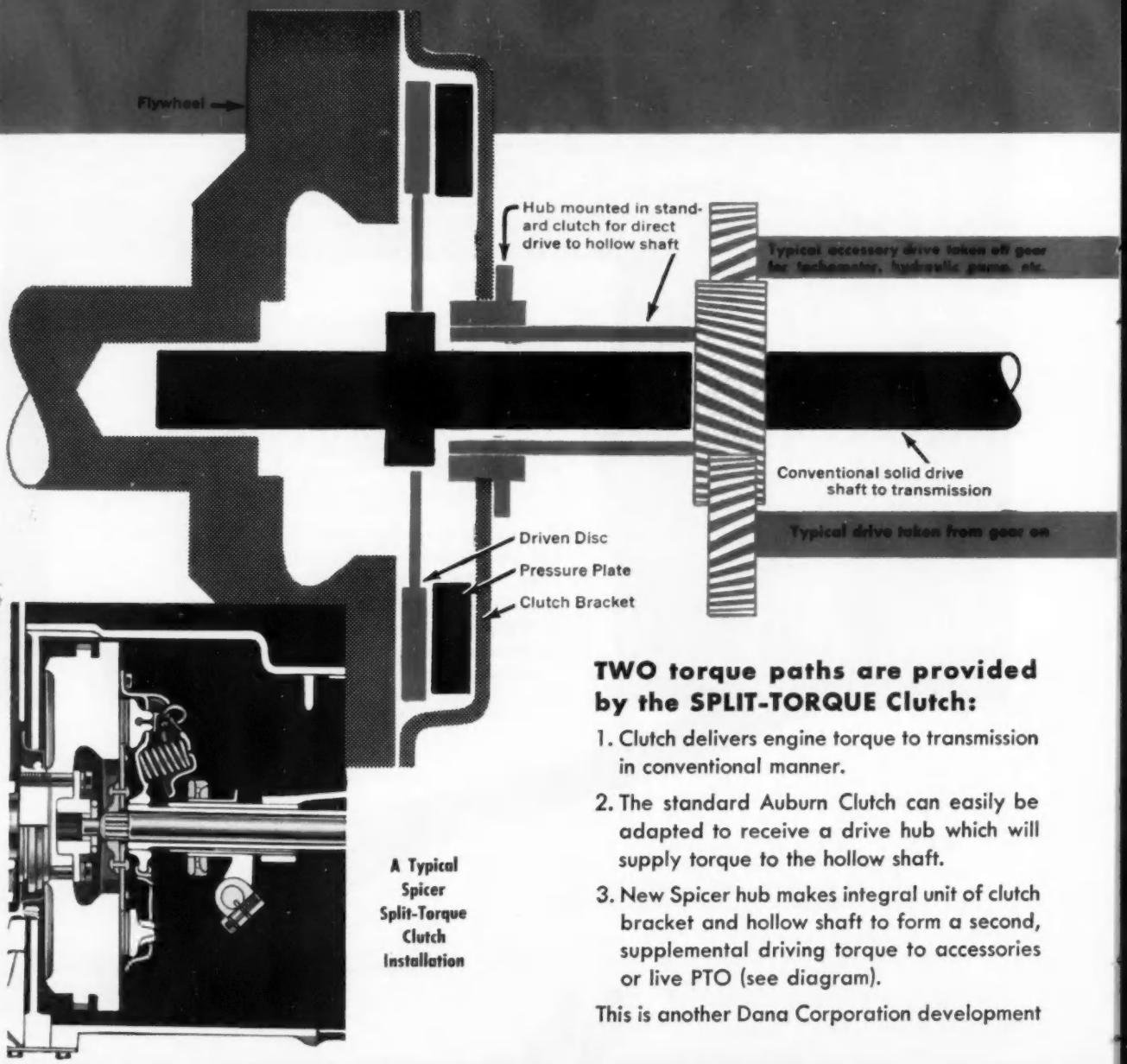
STOCK SPECIFICATIONS—If your production can use mill quantities (20M lb./minimum) in widths up to 8" x nominal thicknesses, ask for quotations!

Detroit Sales Engineering Office
16722 E. Warren Avenue • TUxedo 2-0232

Hunter Douglas Aluminum Corporation

HUNTER DOUGLAS ALUMINUM CORPORATION • DEPT. SA-9, RIVERSIDE, CALIFORNIA • OVerland 3-3030

The New Spicer SPLIT


Flywheel
Hub mounted in standard clutch for direct drive to hollow shaft
Typical accessory drive taken off gear for tachometer, hydraulic pump, etc.
Conventional solid drive shaft to transmission
Typical drive taken from gear on
Driven Disc
Pressure Plate
Clutch Bracket

A Typical Spicer Split-Torque Clutch Installation

TWO torque paths are provided by the SPLIT-TORQUE Clutch:

1. Clutch delivers engine torque to transmission in conventional manner.
2. The standard Auburn Clutch can easily be adapted to receive a drive hub which will supply torque to the hollow shaft.
3. New Spicer hub makes integral unit of clutch bracket and hollow shaft to form a second, supplemental driving torque to accessories or live PTO (see diagram).

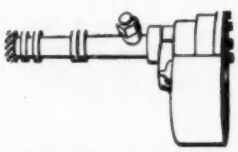
This is another Dana Corporation development

DANA CORPORATION • TOLEDO 1, OHIO

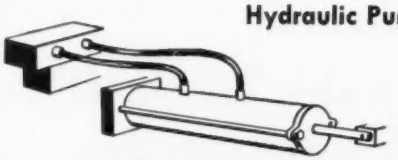
TORQUE CLUTCH

Provides TWO Torque Paths from ONE Power Source to do TWO DIFFERENT Power Jobs!

Tachometer

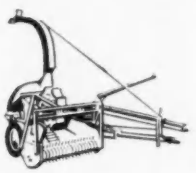


Hydraulic Pump

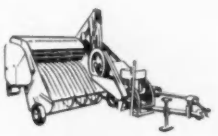


—and other accessory requirements

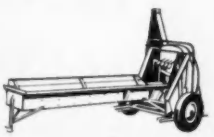
hollow shaft to live Power-take-off



Hay Pick-Ups

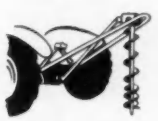


Balers



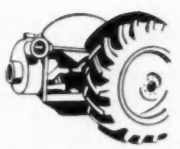
Forage Blowers

Elevators

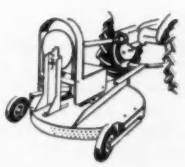


Post Hole Diggers

Sprayers



Irrigation Pumps



Rotary Mowers

—and other farm implements

to help make farm implement operation more simple, efficient, and profitable. Already several tractor manufacturers have adopted the new Spicer Split-Torque Clutch as standard equipment.

The Spicer Split-Torque Clutch, in P.T.O. operations, can eliminate gear shifting and two-thirds of the wearisome de-clutching and re-clutching work.

Simplicity of design, easy adaptability and strong sales features make this new Spicer Clutch desirable as an addition to your farm tractor specifications.

Spicer

SPICER PRODUCTS: TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • AXLES • TORQUE CONVERTERS • GEAR BOXES • POWER TAKE-OFFS POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • STAMPINGS • SPICER and AUBURN CLUTCHES • PARISH FRAMES • SPICER FRAMES

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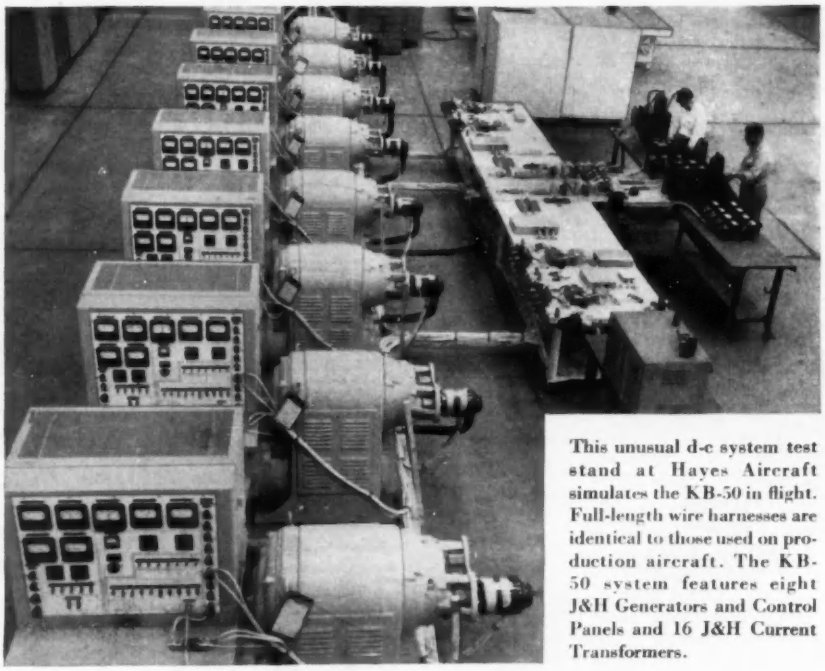


This unusual d-c system test stand at Hayes Aircraft simulates the KB-50 in flight. Full-length wire harnesses are identical to those used on production aircraft. The KB-50 system features eight J&H Generators and Control Panels and 16 J&H Current Transformers.

8 Jack & Heintz Generators paralleled in unique d-c system!

. . . engineers achieve 78% more power for KB-50

The KB-50 will have tremendous refueling capacity. Plans call for fueling of three planes simultaneously.

Jack & Heintz G23 Generator

Rating—amp	400
Voltage—d-c	30
Speed Range—thousand rpm	3.8-8
Weight—lb	67
Dimensions—inches	
Over-all Length (from mounting flange)	13 31/32
Over-all Diameter	8
Bolt Circle Diameter	5
Spline, Pitch Diam	.8
Air Inlet Conn., OD	3
Cfm of Air at 6" H_2O & 6000 rpm	165
Rotation as Viewed from end Opposite Flange	CW

In converting the Boeing B-50 Superfort into the KB-50 mid-air refueling tanker, a substantial power boost was needed to drive the array of rapid-transfer fuel pumps honeycombed throughout the plane.

The approach lay in developing a new higher rated generator or in paralleling eight available 400-amp machines.

The Jack & Heintz G23 d-c Generator proved to be the answer. Rugged enough to withstand the high vibration characteristics in the KB-50, this generator required only a specially machined housing and a modified mounting flange.

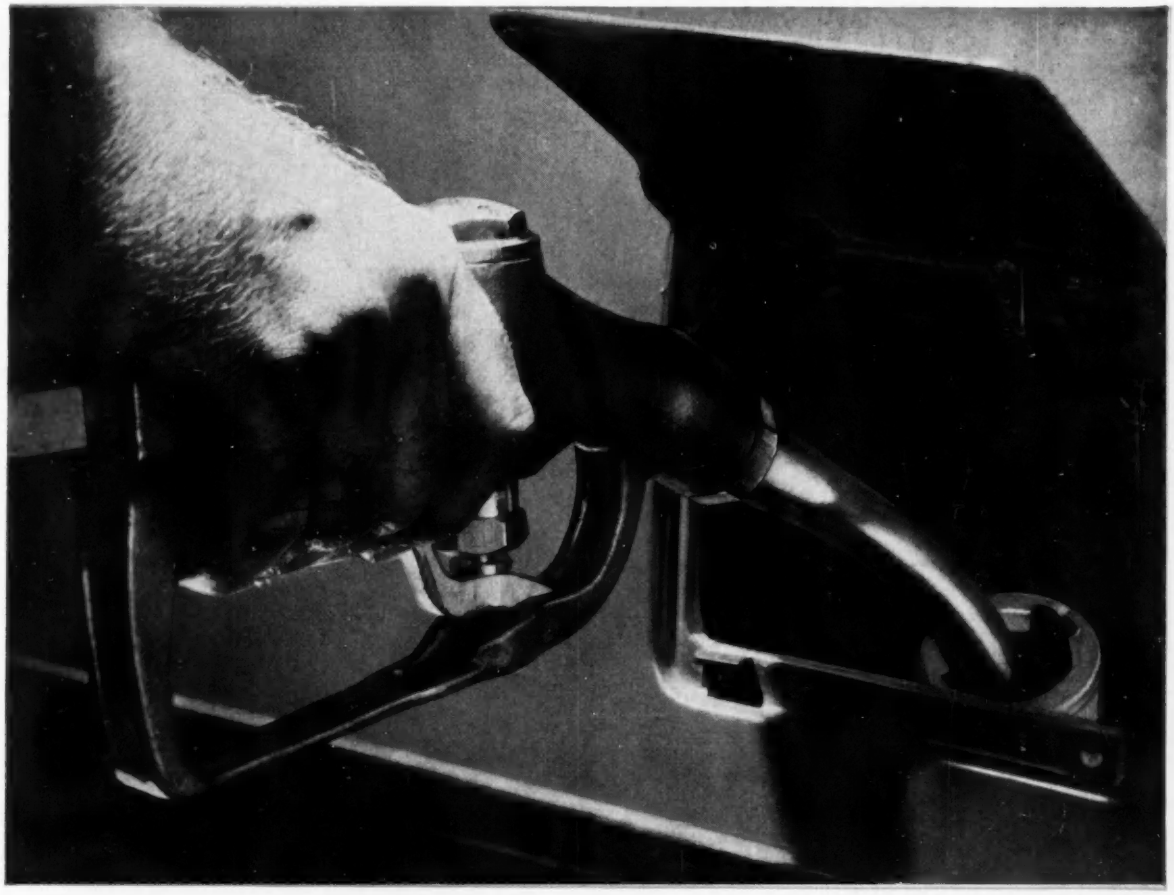
Through the use of the G23, Hayes and Jack & Heintz engineers have achieved a power supply of 3200 amps in the same available space once yielding a maximum of 1800 amps. The unprecedented paralleling of eight generators has been test-proved completely reliable.

Also available is a modified G23 with an increased rating of 450 amps, which is ideally suited to airline applications.

For complete information, write Jack & Heintz, Inc., 17638 Broadway, Cleveland 1, Ohio. Export Dept.: 13 E. 40th St., New York 16, N. Y.

©1956 by Jack & Heintz, Inc.

JACK & HEINTZ *Rotomotive* **AIRCRAFT EQUIPMENT**



Can STROMBERG—champion economy carburetor—help sell cars?

The question is directed to manufacturers whose cars are not yet equipped with Stromberg Carburetors. Car makers using Stromberg now are also using its outstanding economy record in the Mobilgas Economy Run to convince thousands of economy-minded customers.

A large segment of your market—people in every income bracket—is always motivated by economy of operation as well as style, power and other good features. Proof that the motor car industry is well aware of this fact is its participation in the Mobilgas Economy Run every year, knowing how much a victory helps new-car sales.

Stromberg-equipped cars have won the coveted Sweepstakes Award in this national economy tournament two straight years!

If economy is a touchy subject instead of a good, solid selling feature with your line of cars, it will pay you to make comparative efficiency tests with Stromberg Carburetors against the field.

Remember, for more than forty years more advances in carburetion have been initiated by Stromberg than any other manufacturer. Stromberg application engineers are at your service.

ECLIPSE MACHINE DIVISION OF BENDIX AVIATION CORPORATION

Original Equipment Sales: Elmira, N.Y. • Service Sales: South Bend, Ind.
Export Sales and Service: Bendix International Division, 205 E. 42nd Street, N.Y. 17, N.Y.

Stromberg* Carburetor Bendix* Electric Fuel Pump Bendix* Folo-Thru Starter Drive

*REG. U.S. PAT. OFF.

ECLIPSE
MACHINE DIVISION
ELMIRA
NEW YORK

Bendix
AVIATION CORPORATION

NEW

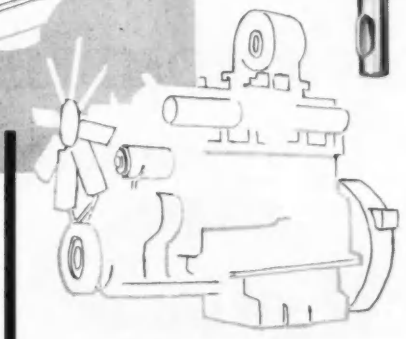
Tachometer Take-Off

...for VEEDER-ROOT Rev-Counters

With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:



Everyone... Can Count on

VEEDER-ROOT

INCORPORATED

HARTFORD 2
CONNECTICUT

New York 19, N. Y.
Greenville, S. C. • Chicago 6, Ill.
Montreal 2, Canada
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Get your brake or transmission idea "off the board and on the road"...faster!
FACILITIES OF
American Brakeblok
—SINTERMET
Research and Test — Mahwah, N. J.
Road Test — Toms River, N. J.
" Jennerstown, Pa.
Production — Winchester, Va.
Cleveland, O.
Hillburn, N. Y.

Why American Brakeblok can slash time and still meet toughest specs

Research: Your new friction engineering problems may already be solved, or are well on the way to solution. Hundreds of formulas for asbestos-base, semi-metallic and metallic friction materials have been developed by our research staff, and are ready now for tomorrow's needs.

Testing: Continuous testing in the lab and on the road enables us to provide comprehensive reports covering every factor influencing performance and service life. In many cases, this service saves our customers weeks of exhaustive testing.

Production: Three modern plants in the U. S. A. can meet the needs of millions of vehicles and machines every year. Point-by-point production, precisely controlled, insures top quality of every part.

Service: Sales engineers are your liaison with ABB. They know their field, and are at your disposal—virtually members of your project team. Even when design changes in midstream, they can shift ABB to meet the new requirements immediately.

• • •

To take full advantage of these American Brakeblok facilities, we suggest you check with us during your initial planning stage. A call or letter will bring immediate action.

Brake Shoe

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

Which one will qualify as a missile engineer?

All—or none—depending on three important points! The desire for a *real* engineering challenge. The ability to work with a top team of experts in their respective fields. The capacity to take on individual responsibility.

If this sounds like a lot, it's because North American Aviation has a lot to offer. With research, development and manufacturing responsibility for the U. S. Air Force SM-64 Navaho Intercontinental Missile, the scope of the art at North American is wide and the opportunity to assume a position of authority great. In fact, all phases of this project—research, design, development and testing—are being accomplished by North American engineers.

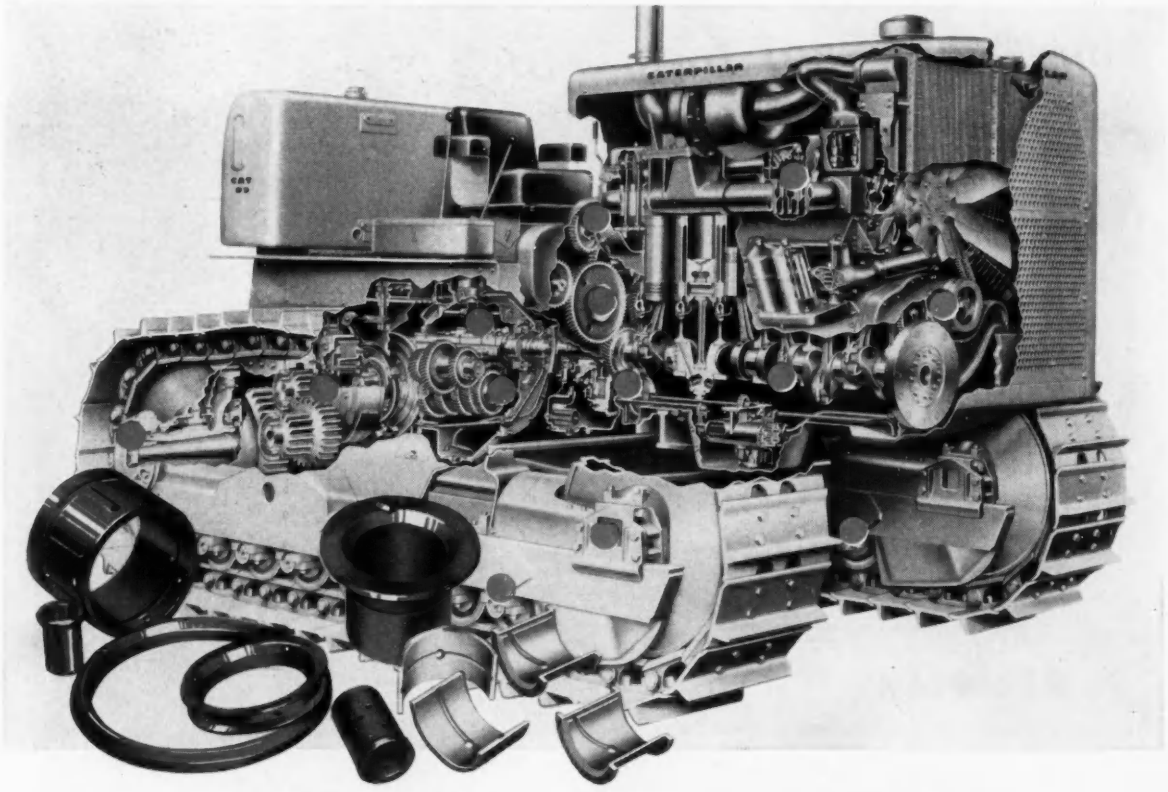
And what benefits will you find in this type of engineering environment?

First of all—recognition that comes from the opportunity for individual effort. You will work with engineers who respect your opinions and professional status. Because missile engineering covers so many fields, you can work in the area of your choice. You will work on a team of specialists whose leadership in their fields will further you in the one you choose. You will live in Southern California and receive financial compensation limited only by your own ability.

If you have the desire for a real engineering challenge—Investigate Now.

Contact: Mr. M. Brunetti, Missile Engineering Personnel
Dept. 91-9SAE, 12214 Lakewood Boulevard, Downey, Calif.

NORTH AMERICAN AVIATION, INC.



Dependable Johnson Bearings

Help Give Long Life To Big Cat Machinery

Engine bearings and bearings in track rollers and other components play a big role in the ability of Caterpillar Diesel Tractors to give long, satisfactory performance on tough jobs.

Caterpillar Tractor Co., manufacturers of the big yellow, earth moving rigs you see at every hand, makes certain that each part has the quality and stamina to give trouble-free service.

The ability of Cat equipment to handle difficult assignments depends in part on bearings obtained from Johnson Bronze Company of New Castle, Pa., which supplies a wide variety of the bearings used throughout Caterpillar products.

Dependable Johnson bearings—made of aluminum on steel, babbitt on steel, cast bronze, bronze on steel, and sintered bronze powder (Ledaloyl)—help Caterpillar meet its triple objective of: 1. durability, 2. bigger pay loads, and 3. longer life. Johnson also offers Caterpillar sound engineering help, has a complete line, maintains uniform high quality and consistently meets Caterpillar's specifications.

This is a typical example of the service Johnson gives many manufacturers in all industry by supplying them with many types of bearings for a wide variety of applications—from automobiles to sound recorders—from automatic washers to machine tools—to name but a few.

To enjoy the dependability and economy of Johnson bearings in your products, write for information on how Johnson engineers will work with you to make a better product at lower cost. Johnson Bronze Company, 675 S. Mill Street, New Castle, Pennsylvania.

Johnson Bearings

LEDALOYL (powder metallurgy) • ALUMINUM ON STEEL • BRONZE ON STEEL • STEEL AND BABBITT • CAST BRONZE

You might wait forever for another opportunity like this . . .

ATOMIC POWER

Here is a once in a lifetime opportunity for you if you are an ambitious engineer. Take this unique opportunity to become associated with an excitingly new organization. Participate in provocative assignments that go far beyond simply whetting your creative appetite . . . assignments that hold the promise of limitless professional growth.

REACTOR CONTROL

Graduate Electrical Engineers for the development of control systems for Atomic Power reactors. General control experience in power station, aircraft, marine vessels, or automatic machinery desirable. Broad responsibility from specifications to installation and operation.

POWER PLANT

Graduate Mechanical Engineers for component specifications, design, manufacturing and installation of pressure vessels, valves, pumps, heat exchangers, and high pressure piping. Systems and arrangements engineers. Special need for welding engineers and materials and process engineers.

QUALITY ENGINEERING

Graduate Engineers for standards development in radiography, ultra-sonics, and other non-destructive testing techniques.

Senior quality control engineers with mechanical engineering degree or extensive background in high precision machinery. Experience in stainless steels, heavy manufacturing highly desirable.

Plant located in one of the most desirable suburban Pittsburgh communities

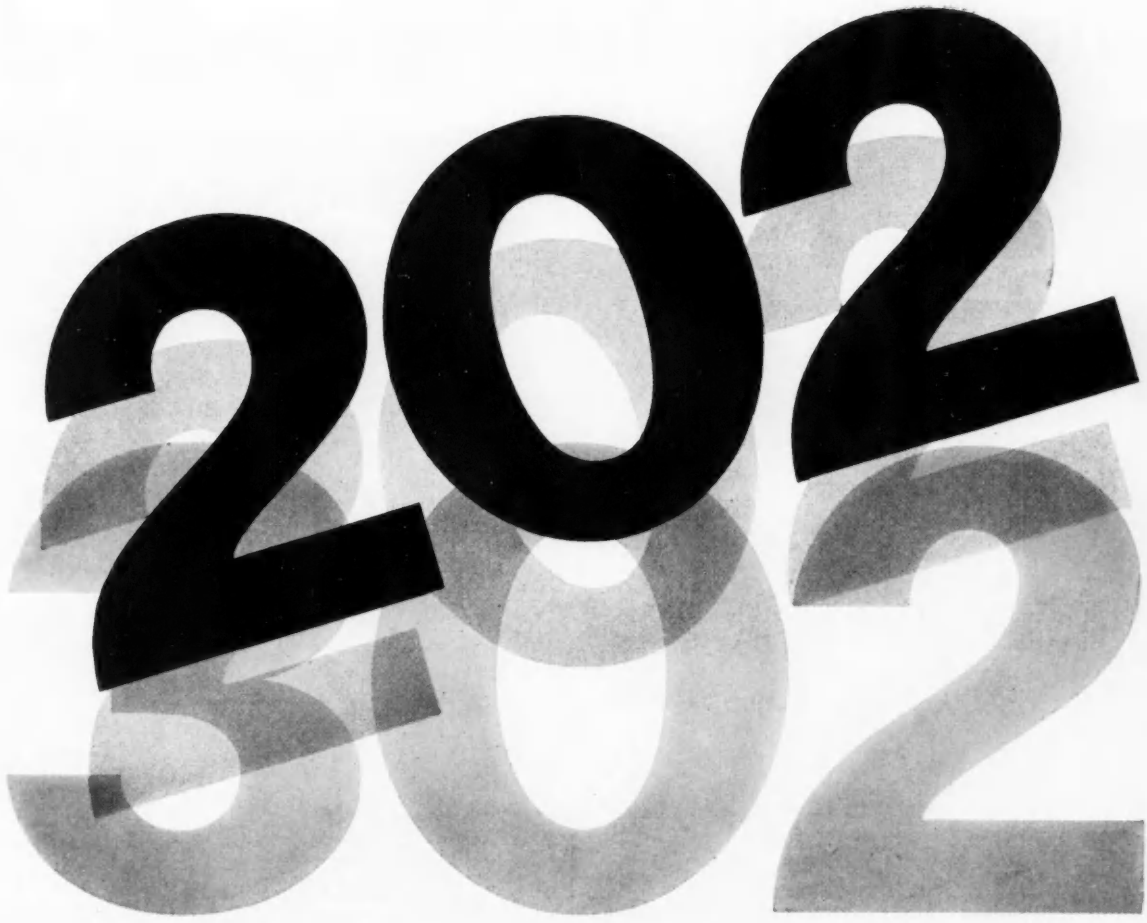
Applicants who meet our requirements will be invited to visit us at our expense.

Send complete resume to:
MR. JOHN BATEY

Westinghouse

ELECTRIC CORP.

P. O. BOX 1047
PITTSBURGH, PENNA.



now, Crucible low nickel stainless steels that meet many of your needs...

Here are two *new* Crucible grades, Rezistal type 201 and 202 that are similar in quality and properties to types 301 and 302 . . . but with desirable features all their own.

In the annealed condition, for example, Rezistal 201 and 202 have about 10% higher strength than 301 and 302, yet maintain almost identical ductility. This means that these grades can be fabricated with ease equal to their counterparts. In addition, their mill finishes and corrosion resistance to a wide variation of media compare most favorably with 301 and 302.

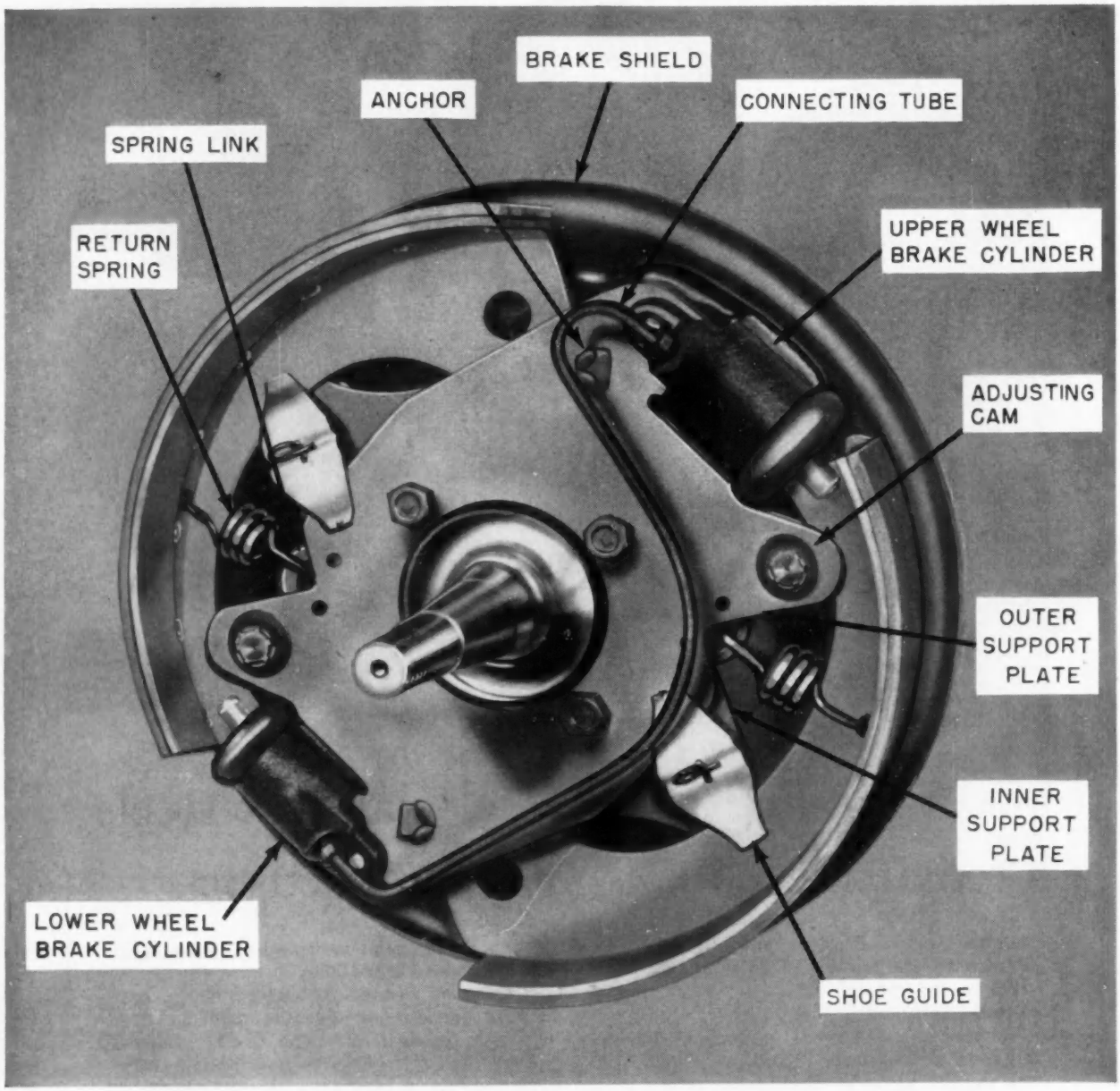
To sum up: Rezistal 201 and 202 have practically all the desirable properties of 301 and 302, *plus* some of their own. And they're available *promptly* in all forms. Write now for data sheets fully covering the properties of these new stainless grades. *Crucible Steel Company of America, Dept. ASA, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

Bundyweld Tubing specified



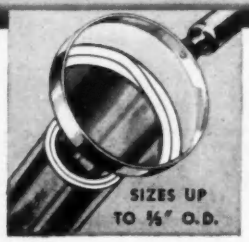
WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniformthickness,and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.



← NOTE the exclusive Bundy-developed beveled edges, which afford asmootherjoint, absence of bead, and less chance for any leakage.

by Chrysler for advanced, new center-plane brakes

Dependable double-walled steel tubing is used in 95% of today's cars, in an average of 20 applications each

Chrysler's famous FORWARD LOOK is more than skin-deep. One of the unseen advances is in its new center-plane brakes, where mechanical linkage has been replaced by an ultra-dependable internal hydraulic system. From brake pedal to brake shoe, the Chrysler's "stopping" power now relies on Bundy® Tubing.

Fuel, lubrication, brake, or control lines—you just can't beat Bundyweld for strength and dependability. Used on all major automobiles, it is the tubing standard of the industry.

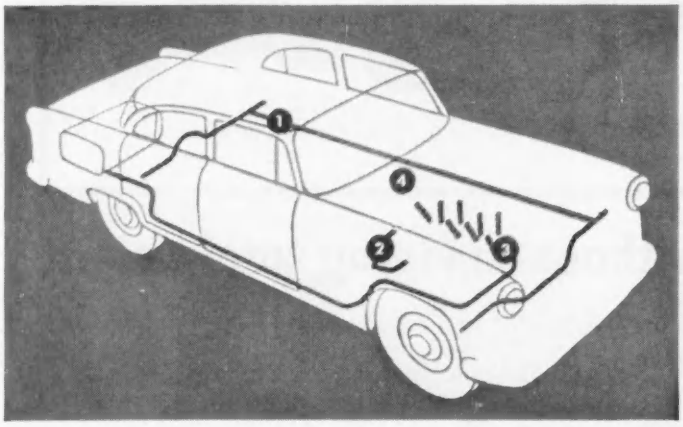
Bundyweld is leakproof by test; thinner walled yet stronger; has high bursting strength; takes easily to standard protective coatings; has high fatigue limits. It's the only tubing double-walled from a single metal strip; copper-brazed throughout 360° of double-walled contact.

In addition, Bundy offers you unexcelled fabrication facilities, expert engineering services; custom packaging of orders; prompt, *on-schedule* deliveries. Whether you fabricate your own parts or want us to do the job, we're equipped to handle your order—exactly to your specifications.

Call, write, or wire today for complete information or for specific help with your problem.

BUNDY TUBING COMPANY • DETROIT 14, MICH.

BUNDYWELD STEEL TUBING—"LIFELINES" OF YOUR CAR



1
Bundyweld lifelines in your car's hydraulic brake system are *many times stronger than necessary to save your life.*

2
Leakproof Bundyweld helps keep oil where it belongs in your car—with no delays, costly repairs, ruined engine.

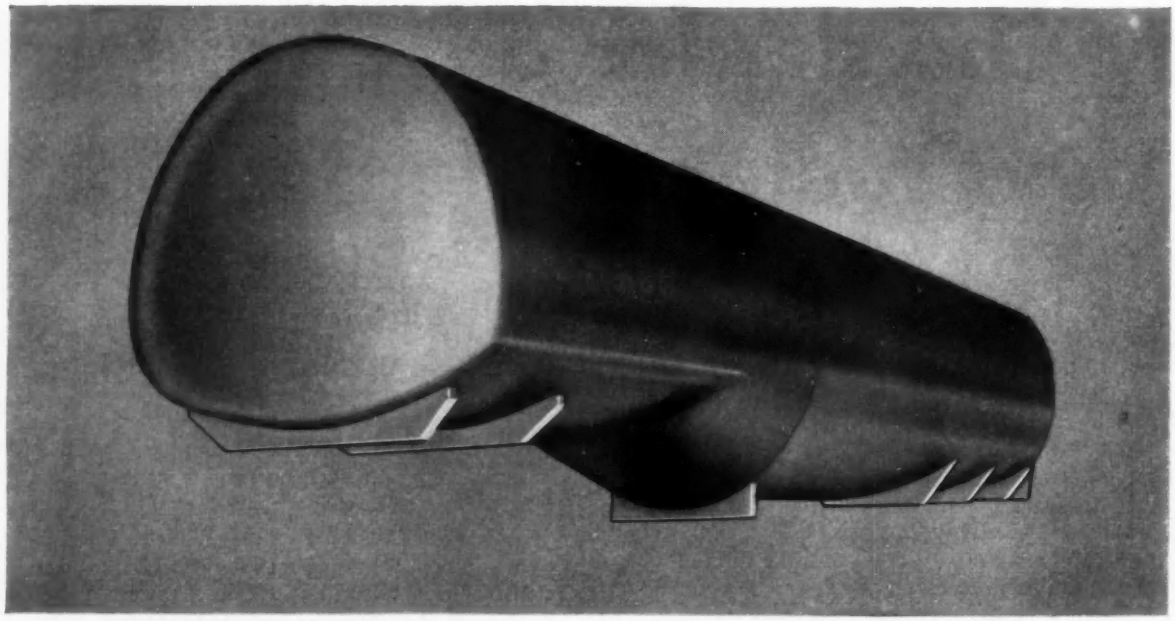
3
Fuel lines of Bundyweld won't fail you, despite constant beating from flying rocks, punishing vibration.

4
To help keep push-button windows foolproof, manufacturers depend on Bundyweld to conduct the hydraulic fluid.

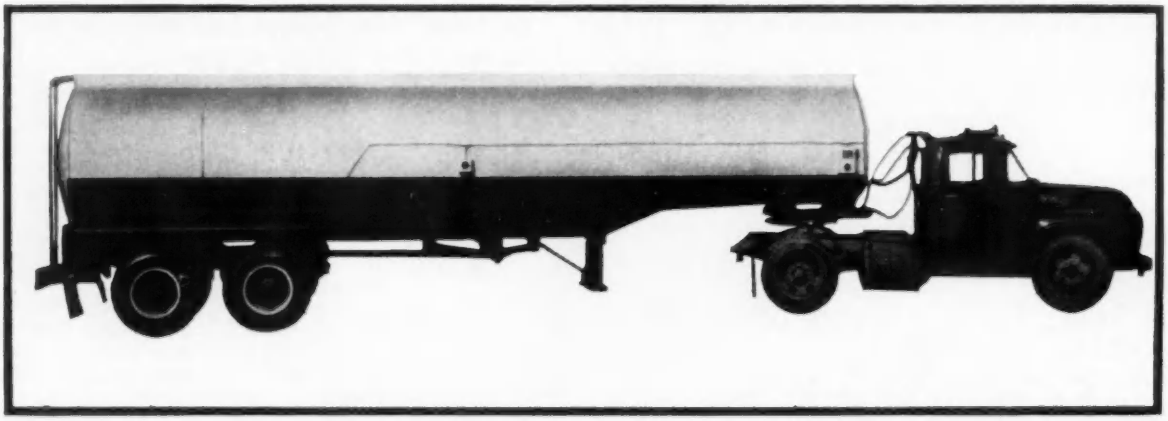
BUNDYWELD® TUBING

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Pelson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**



Nickel-Copper high strength low alloy steel helps Butler Manufacturing Company, Kansas City, Mo., increase capacity of frameless unit . . . enabling transport to haul . . .



2000 lb more payload without changing total weight

Without increasing axle load, increased revenue per ton mile is made practical by use of high strength low alloy steels containing nickel.

Steels of this type show 50,000 psi minimum yield point, or about 1½ times that of the usual carbon grade. This, together with improved corrosion resistance, allows use of thinner sections and permits following either of these two procedures:

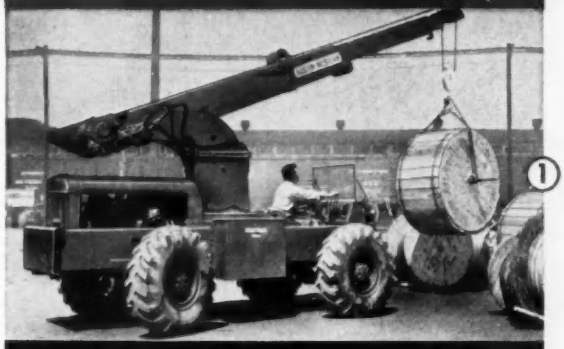
(1) Reduce weight... saving tires, brakes and fuel... without reducing strength of equipment.

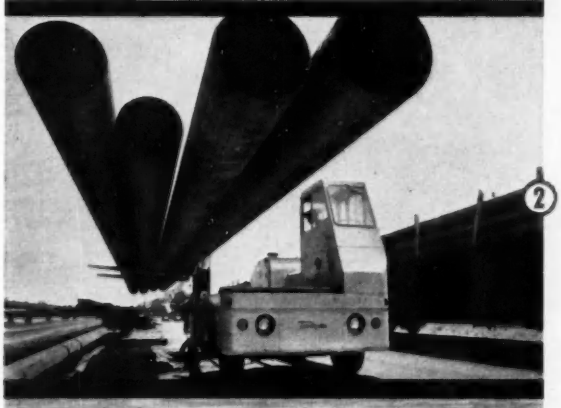
(2) Increase payload capacity without increasing total weight or power demands.

Send for a copy of "Nickel-Copper High Strength Low Alloy Steels."

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

NEW VEHICLES
FOR
NEW PERFORMANCE





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HYDRAULIC SYSTEMS

for All Types of

MOBILE

EQUIPMENT

Vickers Hydraulic Systems make vital contributions to the efficient operation of an extremely wide range of vehicles. To the inherent advantages of hydraulic control, Vickers adds the benefits of a nation-wide and full time field engineering and service organization of unequaled experience. Vickers has the complete line of hydraulic equipment necessary to take undivided system responsibility . . . to eliminate any risk of incompatibility of hydraulic components. Ask for a copy of Bulletin M5101.

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DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
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Engineers and Builders of Oil Hydraulic Equipment Since 1921

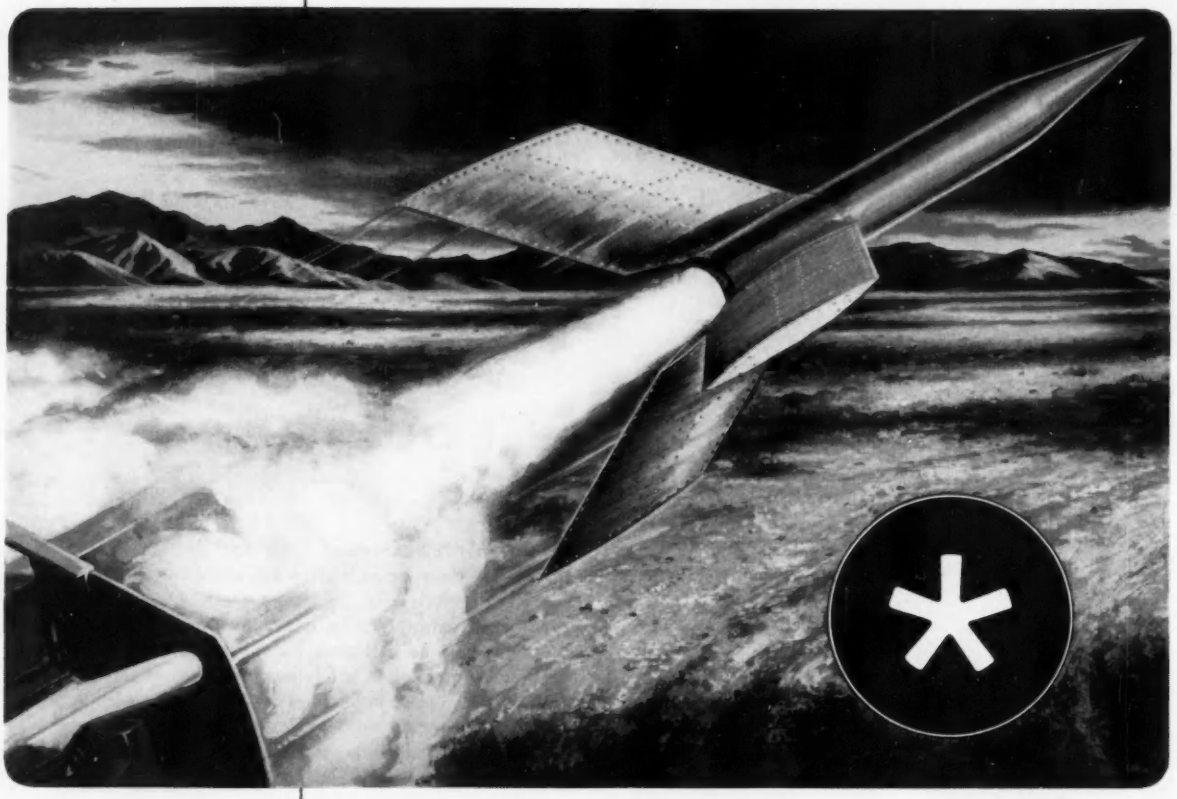
7354

① **AUSTIN-WESTERN HYDRAULIC CRANE**
In addition to power steering, Vickers Oil Hydraulics provide fast, smooth and positive (a) turntable rotation, (b) boom elevation, (c) raising and lowering of load, (d) extending and retracting of boom.

② **BAKER-RAULANG TRAVELOADER**
Vickers Hydraulics provides power steering and multiple movements that enable Traveloader to quickly reach out sideways and pick up a long load, place it on the vehicle's deck for traveling, and then stack it up to 12' high.

③ **DART UNDERGROUND TRUCK**
Vickers Hydraulics operates the reversible conveyor floor that permits fast and easy trim when loading, and then rapid dumping. Also has Vickers Hydraulic power steering for shuttle operation.

IMPORTANT DEVELOPMENTS AT JPL



Pioneering in Solid Propellant Rockets

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1450 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers. Inquiries now invited.

The successful flight of the Thunderbird, a short-range test rocket, accomplished a real pioneering achievement at the Jet Propulsion Laboratory in 1947. It was a noteworthy demonstration of a new technique which has since revolutionized the field of solid-propellant rockets.

In the Thunderbird a mixture of oxidizer and synthetic rubber fuel was poured around a star-shaped core set in a cylindrical casing forming as it solidified a permanent bond with the metal shell. The removal of the core leaving a hollow center made possible the even burning of the propellant from the center outward. The insulating effect of the unburned propellant permitted the use of an unusually thin casing due to heat reduction.

This technique led the Laboratory into a number of new developments in missile design which have since been applied to powerplants in many current and forthcoming missiles.

Such activities in research and development are in constant progress at JPL, providing stimulating opportunities to individuals desiring to devote themselves to the areas of basic and applied research and to actual development engineering.

JOB OPPORTUNITIES IN THESE FIELDS NOW

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A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY
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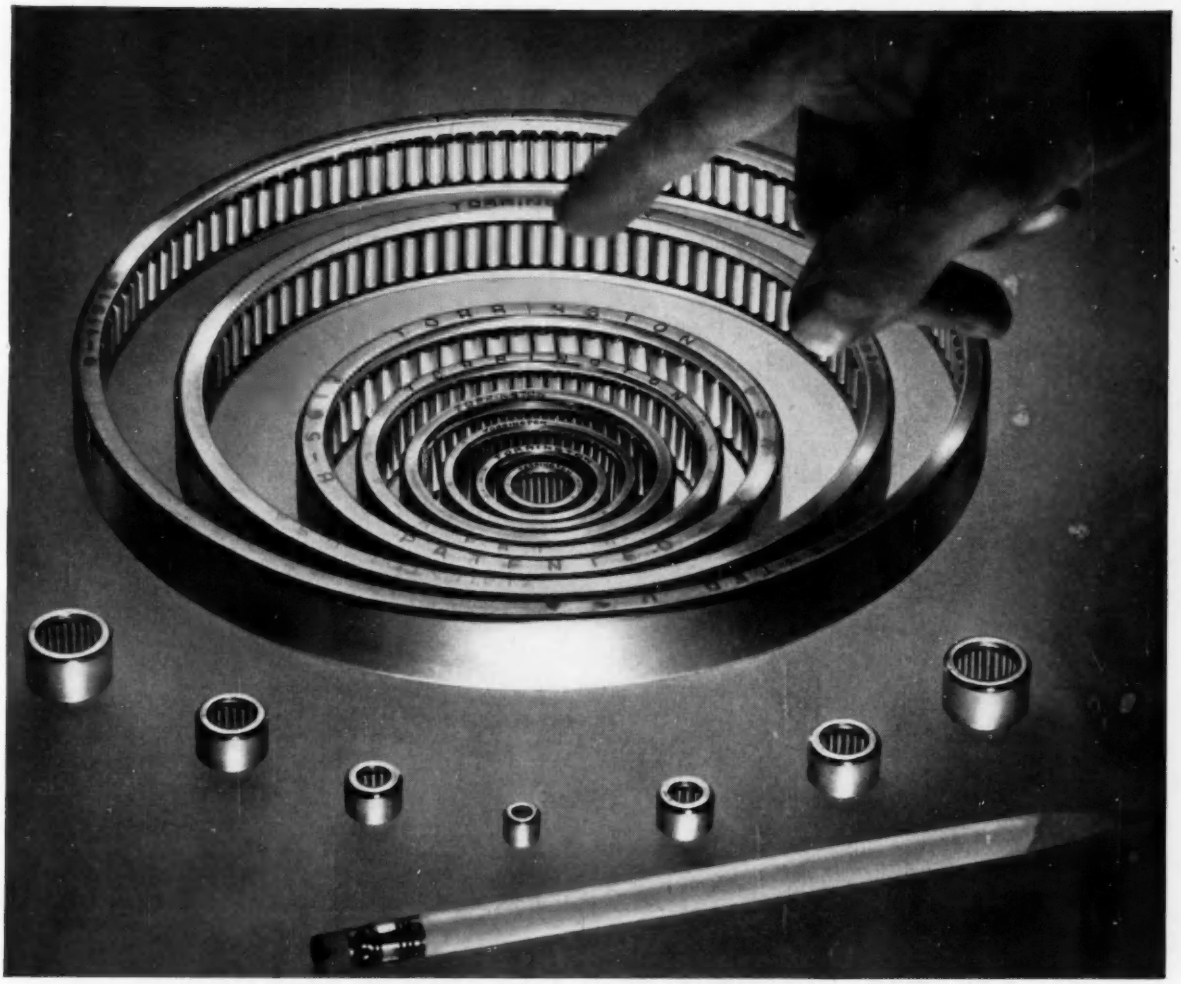

TORRINGTON NEEDLE BEARINGS
come in large sizes too!

Meeting the needs of designers for more compact, higher capacity anti-friction bearings in thousands of applications, Torrington Needle Bearings are made in a range of sizes for shafts from ⅛" up to 7¼" in diameter. Several widths are available in most sizes to meet different application requirements.

In the large sizes as in the small, basic design advantages are the same. Unit cost is low and radial load capacity is greater than any other anti-friction bearing of the same size.

Large Needle Bearings are doing big jobs in transmissions, steering gears, suspension and starting motors of farm tractors and earth-moving machinery. They have also been used for many years in industrial hydraulic pumps.

To gain the advantages of the unique Torrington Needle Bearing in your product, enlist the knowledge and skill of our Engineering Department.

See our New Needle Bearing Catalog in the 1956 Sweet's Product Design File —or write direct for a catalog.

TORRINGTON NEEDLE BEARINGS
Give you these benefits

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

Usable beauty for exacting service...

STAINLESS STEEL

A metal of *Sterling* Qualities

Strong, practical, durable... easy to clean and keep clean... that's stainless steel.

Air, water, fumes, road dirt and chemicals don't affect it. And the beauty is clear through—not skin deep. Stainless never peels, flakes or grows permanently dingy. It's luster lasts a lifetime. Its brilliance can be restored with ordinary cleaning. And the harshest cleaners can't harm it. Stainless steel does not easily dent or gouge—but if such damage does occur corrosion resistance remains.

Truly stainless steel is a metal of sterling qualities. It belongs on all fine cars wherever economy and ease of fabrication are a prime consideration... styling and elegance are desired.

Your supplier has the particulars. Contact him today. And remember:

The finest stainless steels are made with Vancoram Ferro Alloys.

VANCORAM

Producers of alloys, metals and chemicals

VANADIUM CORPORATION OF AMERICA

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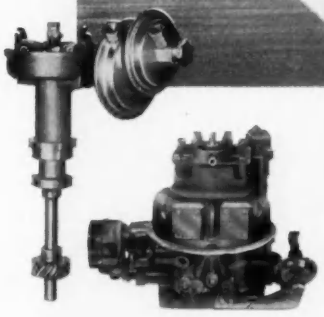
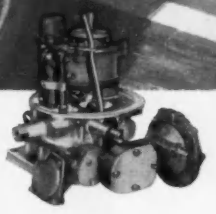
Over 50 Years of Progress
1906 · 1956



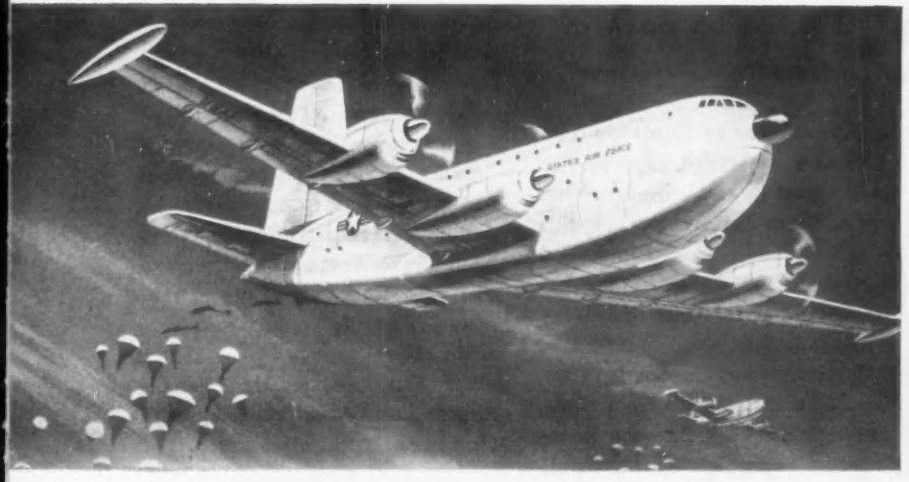
IN AUTOMOBILES—over 10 million of them—you'll find Holley carburetors and distributors. Holley's outstanding record of "firsts" in this field includes the 4-barrel carburetor with vacuum controlled secondary barrels.

IN TRUCKS. More of America's truck engines are Holley carburetor equipped today than are equipped with any other carburetor. Leading truck manufacturers combine Holley's carburetor, distributor and governor for an integrally-designed control system which provides maximum power and maximum economy features.



Engine Control Systems by Holley

"Mechanical Brains" to Control the Power of the Engines of America



Effective control of engine power is not a simple process of fuel metering—rather it is a problem of co-ordinating the many variables in such a way that the pilot's or driver's demand is instantly satisfied in the optimum manner.

For over half a century, Holley has supplied control systems to harness the power of automobile, truck and aviation engines of all types. Holley carburetors and distributors for automobiles and trucks, and turbine controls for jet aircraft provide maximum efficiency and minimum operating costs for today's engines.

Wherever control systems are needed — for auxiliary or main power plants — Holley's half a century of design, engineering and manufacturing experience can best meet your requirements.

IN AIRCRAFT—jet fighters, bombers, and huge airliners of the future—power control systems by Holley automatically make engine adjustments for busy pilots.

HOLLEY Carburetor Co.

FOR MORE THAN HALF A CENTURY —ORIGINAL EQUIPMENT MANUFACTURERS FOR THE AUTOMOTIVE INDUSTRY.

11955 E. Nine Mile Road, Van Dyke, Michigan

24

TRUCKING . . . Vital Transportation Link

Transmission Repairs only .0003c (3/10 mill) per mile at SUPER SERVICE

after an average of 210,176 miles on each of 172 Fuller Transmissions

"With the Fuller ROADRANGERS in our fleet, we've hit an all-time low in transmission repair costs," says Ray Carter, Director of Engineering for Super Service Motor Freight Co., Nashville, Tennessee.

Super Service recently completed a careful check of maintenance records for 172 White tractors equipped with Fuller 10-speed Semi-Automatic ROADRANGER Transmissions. With an average of 210,176 miles per tractor, company records showed a remarkable average repair cost of *only .0003c (3/10 of a mill) per mile for each* ROADRANGER *Transmission!*

About two years ago, Super Service standardized its entire over-the-road fleet on White tractors equipped with ROADRANGER Transmissions and Cummins diesel engines. From that time on, old performance records began to fall.

Operating from the South to the East . . . with terminals from Nashville to New York . . . the ROADRANGER equipped tractors pull square nose, 35-foot aluminum trailers that average 52,500 lbs. gross tare weight. The tractors now cut a full hour off the old 10-hour trip time on the Nashville-East run . . . taking rugged Tennessee hills at 35 miles an hour when 15 was considered a good speed with the old equipment.

Super Service cuts running time and maintenance to a minimum by running its rigs straight through from Nashville to New York. Drivers are changed twice . . . but there's no need to warm up a cold engine at each stage of the relay.

For your fleet, get the facts on ROADRANGERS from your truck manufacturer or truck dealer now.

FULLER MANUFACTURING COMPANY
TRANSMISSION DIVISION • KALAMAZOO, MICH.

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

Do your present truck heaters have a ----

PARTS

"Repair or Replace"

WARRANTY

good for one year or

50000

miles?

EVANS

custom-designed truck heaters have it!

Your Evans Truck Heaters *have* to be good! To prove it, Evans backs every single heater they build with a full year—or 50,000 mile—warranty (whichever occurs first). This is your assurance—and your *customers'* too—that Evans Heaters are the *right* heaters for the trucks you build.

What's more, the heaters Evans engineers design and custom-build for you will meet *all* your truck requirements. They will fit *right*—for quick, easy installation. They will deliver all the BTU's needed for maximum driver safety and comfort—under *any* weather conditions. And special, heavy-duty construction means that the owner gets longer service with much less maintenance.

There's an Evans Heater for *every* type commercial vehicle, from local panel delivery truck to giant over-the-road haulers. Why not let Evans solve your truck heating problems, whatever they may be?

FREE Consulting Service and Heater Catalog! At no cost to you, one of our engineers will call to discuss your heater problems for any truck model, present or future. And write now for your free Evans heater catalog! Address: Evans Products Company, Dept. Z-9, Plymouth, Michigan.

EVANS PRODUCTS COMPANY
also produces: *Evanite battery separators; railroad loading equipment; bicycles and velocipedes; and Evaneer fir plywood*

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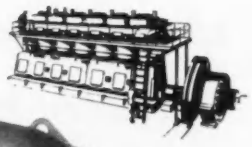
AiResearch Turbochargers

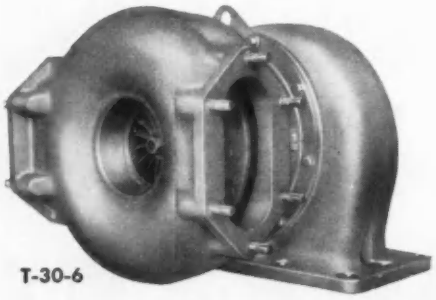
T-10

T-14

These scientifically-engineered turbochargers for your mobile, stationary or marine diesel engines are available now!

T-15





T-30-6

T-30-2

AiResearch has incorporated into the design and manufacture of its turbochargers the greatest experience in the field of small turbomachinery of any company in the world! With these results:

AiResearch turbochargers increase power up to 100%. The only limitation is the design and application of your engine.

Because they *are* air-cooled, they place no extra burden on your cooling system.

They cut fuel costs up to 20%, reduce noise and decrease or completely eliminate diesel smoking.

They're easier to maintain than any other turbochargers. A removable rotating assembly simplifies and reduces maintenance.

They allow your diesels to operate at full efficiency from sea level to more than 8000 feet.

We invite your inquiry on how you can improve the performance of your diesels by the application of AiResearch turbochargers.

BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS

MODEL	T-10	T-14	T-15	T-30-2	T-30-6
Diameter — in. nom.	9	11.5	15.25	15.25	16
Length — in.	9	14.12	16.75	17.25	21.75
Weight — lb.	40	95	125	135	195
Output — lb/min. (Standard Conditions)	25-40	35-65	35-65	70-95	115-175

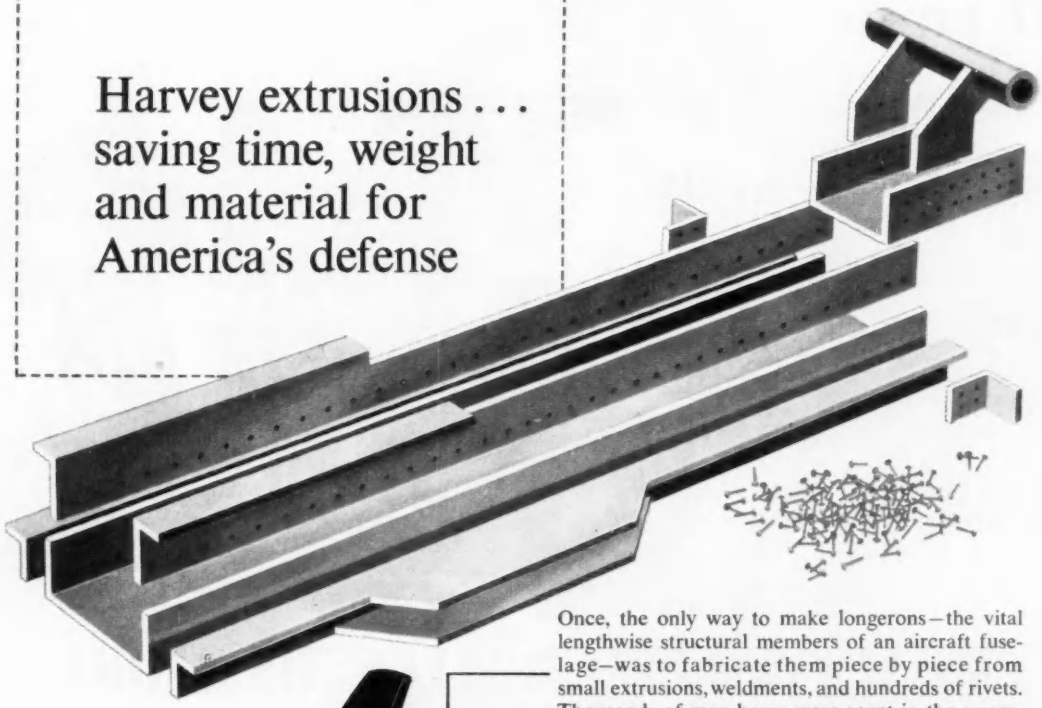
THE GARRETT CORPORATION

AiResearch Industrial Division

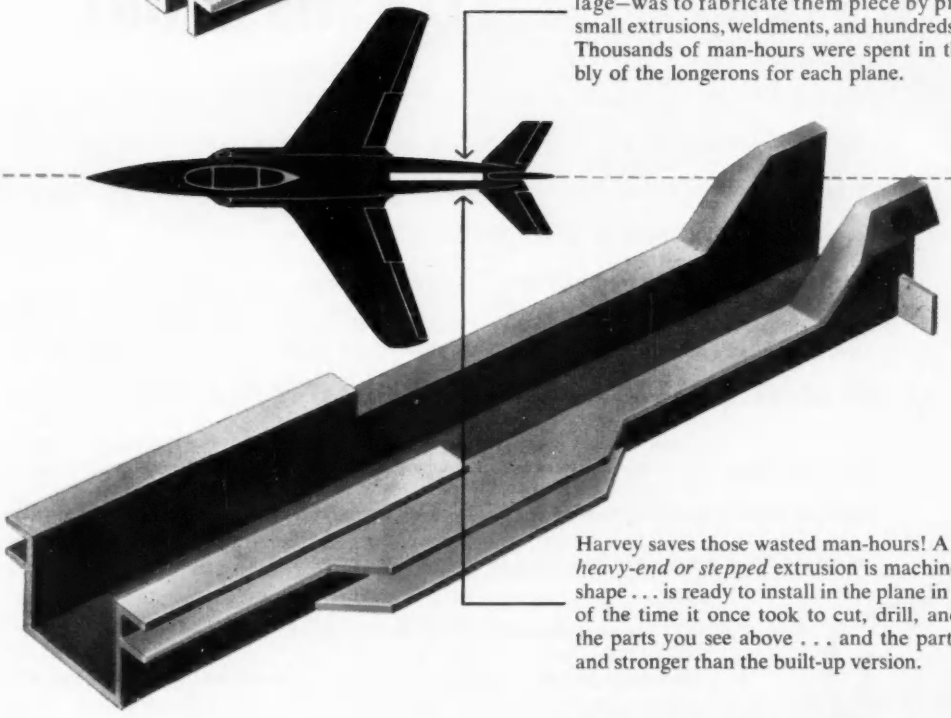
9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

Harvey extrusions . . . saving time, weight and material for America's defense



Once, the only way to make longerons—the vital lengthwise structural members of an aircraft fuselage—was to fabricate them piece by piece from small extrusions, weldments, and hundreds of rivets. Thousands of man-hours were spent in the assembly of the longerons for each plane.



Harvey saves those wasted man-hours! A one-piece *heavy-end or stepped* extrusion is machined to final shape . . . is ready to install in the plane in a fraction of the time it once took to cut, drill, and rivet all the parts you see above . . . and the part is lighter and stronger than the built-up version.

MAKING THE MOST OF ALUMINUM . . . FOR EVERYONE

Harvey is a leading independent producer of aluminum extrusions in all alloys and all sizes, special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tube, impact extrusions, aluminum screw machine products and related products. Also similar products in alloy steel and titanium on application.

HARVEY Aluminum

HARVEY ALUMINUM SALES, INC., TORRANCE, CALIFORNIA—BRANCH OFFICES IN PRINCIPAL CITIES

we're in Milwaukee so we ought to know!

An AC* ENGINEER TELLS HIS STORY

Working at AC, THE ELECTRONICS DIVISION OF GENERAL MOTORS is exciting . . . challenges every inch of my engineering ingenuity, currently I am working on a phase of the Inertial Guidance System Program. A month or two ago I was equally absorbed in our Jet Engine Fuel Control Program. I am certainly growing ENGINEERING "KNOW-HOW-WISE" and my salary checks reflect it. I started at a good salary . . . have had regular increases in salary and position . . . gosh, I like it here.

AND, I enjoy AC's *MASTER'S DEGREE PROGRAM,* University of Wisconsin—Milwaukee. I attend evening classes and AC is paying my tuition *and* with no strings attached.

My family enjoys Milwaukee too. Here in cool, southern Wisconsin we have endless miles of swimming beaches, parks, playgrounds that are ours for the asking. We have the cultural and shopping advantages of the big city in a community long known for its small town hospitality.

P.S. AC's Permanent Expanding Electronic Program provides openings for more Mechanical, Electrical Engineers and Engineering Technicians. Even "square pegs" are provided "square holes" at AC.

Write today in strictest confidence to my friend, Mr. J. F. Heffinger, Supervisor of Salaried Personnel.

*AC THE ELECTRONICS DIVISION

GENERAL MOTORS CORPORATION

Milwaukee 2, Wisconsin • Flint 2, Michigan

Anaconda specifies Enjay Butyl rubber

TO DEFY OZONE IN HIGH-VOLTAGE CABLES...

for more current per circuit...more power per dollar

Anaconda specifies Enjay Butyl insulation for high-voltage cables because this rubber has incredible resistance to ozone. Surpassing the industry's standard three-hour specification test, Enjay Butyl insulation used by Anaconda showed *no injury after 72 hours* of ozone concentration tests—24 times longer than specification requirements. Other rubbers would deteriorate and crack in a fraction of this time.

With the help of Enjay Butyl, millions of feet of Anaconda's cable now in use deliver more current per circuit, more power per dollar.

Perhaps *your* product, too, can be improved with versatile Enjay Butyl. It comes in non-staining grades for white and light-colored parts, offers excellent electrical properties, low price and *immediate availability*. For full information, contact the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

ENJAY

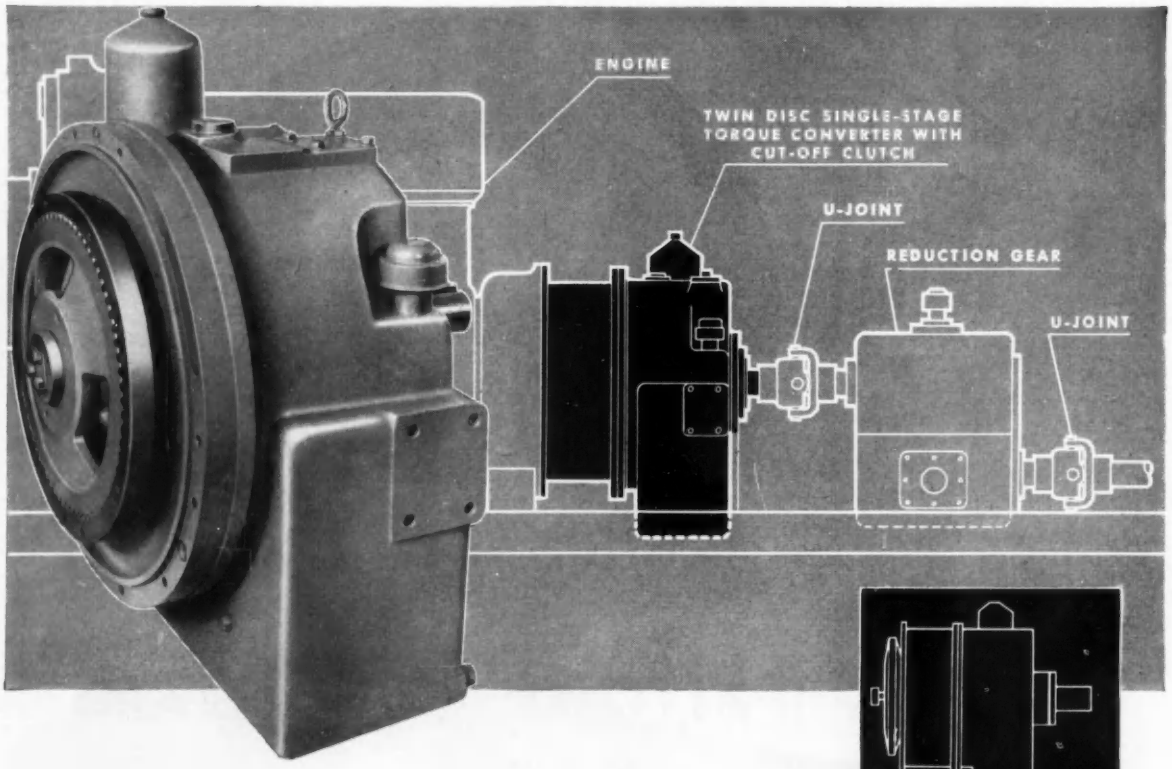
BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa



Design this new *SINGLE-STAGE Torque Converter* into your machine

If your problem is matching single-stage torque converter characteristics to powered equipment, here's the ideal solution: Design the new Twin Disc Single-Stage Torque Converter into your machine!

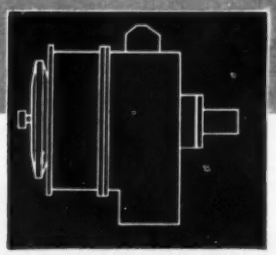
This new single-stage unit is designed and built with all the latest engineering advances—yet retains the basic features that have made Twin Disc Torque Converters the world's most widely used for industrial applications. It's now available in the 1500 Series . . . in a variety of model arrangements . . . in a number of torque capacities . . . from 30 to 207 hp input . . . to meet the widest variety of requirements. Its unique but field-proven design eliminates the need for a free-wheeling device . . . eliminates one more possible trouble spot. Its heavy-duty construction features ample bearing surface throughout . . . for long life and minimum maintenance . . . even where the going is roughest.

Find out more about this new single-stage torque converter . . . how it can help bring out maximum performance in *your* powered products. Write Twin Disc Clutch Company, Hydraulic Division, Rockford, Illinois. Request Bulletin 508.

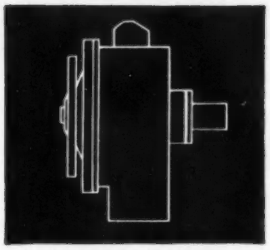
A *complete line* of torque converters, both single-stage and three-stage, for internal combustion engines from 30 to 1000 hp.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

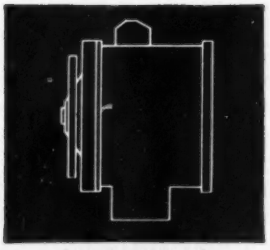
TWIN DISC
Torque Converters



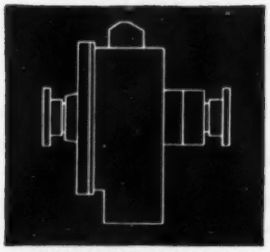
Model "C," with clutch input



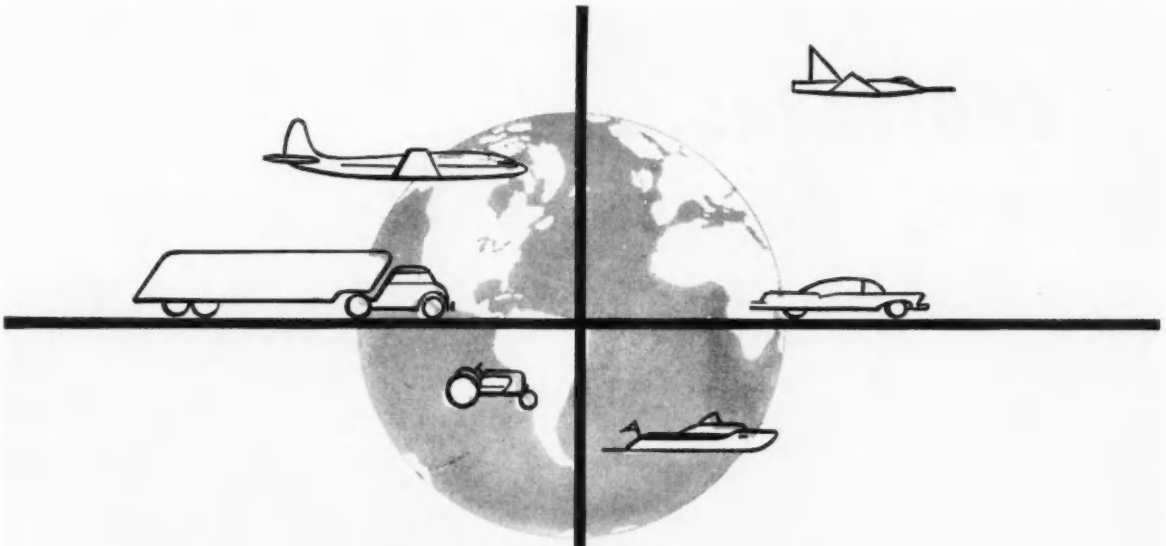
Model "S," with spider drive input



Spacer-Type Model "S"

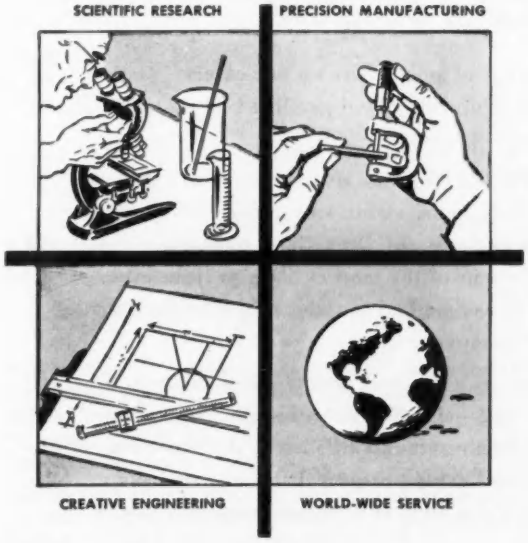


Model "U," with flange input-output



AUTO-LITE | Serves Industry

with more than 400 products of the highest quality



Whether it be intricate die-castings, finely drawn magnet wire, electrical equipment for the automotive industry or any one of hundreds of other products . . . it is of the highest quality when it comes from Auto-Lite. This reputation for quality in 28 plants from Coast to Coast is maintained through central engineering control and is reflected in the public acceptance of the name Auto-Lite . . . and in the world-wide establishment of Auto-Lite service facilities.

THE ELECTRIC AUTO-LITE COMPANY
TOLEDO 1, OHIO

AUTO-LITE

ENGINEERS...

LOOK TEN YEARS AHEAD!

Will your income and location allow you to live in a home like this... spend your leisure time like this?

A Douglas engineer lives here

ANALOG COMPUTING

Those with degrees in mathematics, physics and engineering are needed to solve interesting problems on direct analog computers and differential analyzers.

Knowledge of or experience in dynamics, stress analysis, servomechanisms, heat flow and circuit analysis or non-linear mechanic is helpful.

They can...if you start your career now at Douglas!

Take that ten year ahead look. There's a fine career opportunity in the engineering field you like best waiting for you at Douglas.

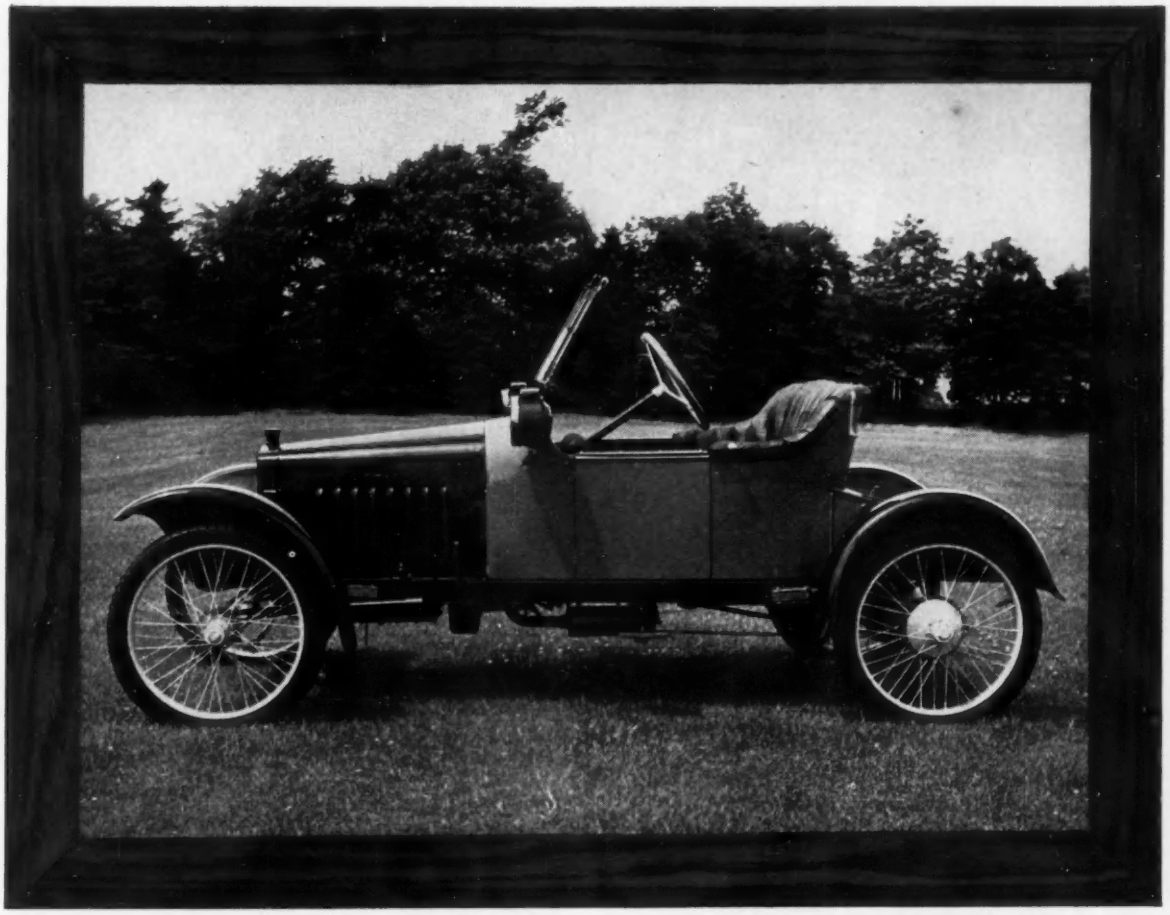
And what about the Douglas Aircraft Company? It's the biggest, most successful, most stable unit in one of the fastest growing industries in the world. It has giant military contracts involving some of the most exciting projects ever conceived . . . yet its commercial business is greater than that of any other aviation company.

The Douglas Company's size and variety mean that you'll be in the work you like best — side by side with the men who have engineered the finest aircraft and missiles on the American scene today. And you'll have every prospect that ten years from now you'll be where you want to be career-wise, money-wise and location-wise.

For further information about opportunities with Douglas in Santa Monica, El Segundo and Long Beach, California divisions and Tulsa, Oklahoma, write today to:

DOUGLAS AIRCRAFT COMPANY, INC.

C. C. LaVene, 3000 Ocean Park Blvd., Santa Monica, California



Send for free print—1914 Saxon Runabout, Model A.
Reprinted by permission—P. S. de Beaumont; not for commercial use.

At $395, the 1914 Model A Saxon Runabout was called "the poor man's light car." It had a 96-inch wheelbase, two-speed transmission, and featured standard tread wheels instead of the very narrow ones then in vogue on cyclecars.

This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing. Morse Chain Company, 7601 Central Avenue, Detroit 10, Michigan.

18 out of 22 automobile manufacturers specify Morse Timing Chain Drives

Ever since mechanical horsepower began replacing nature's variety, the Morse Chain Company has supplied the auto industry with its precision-built Timing Chain Drives.

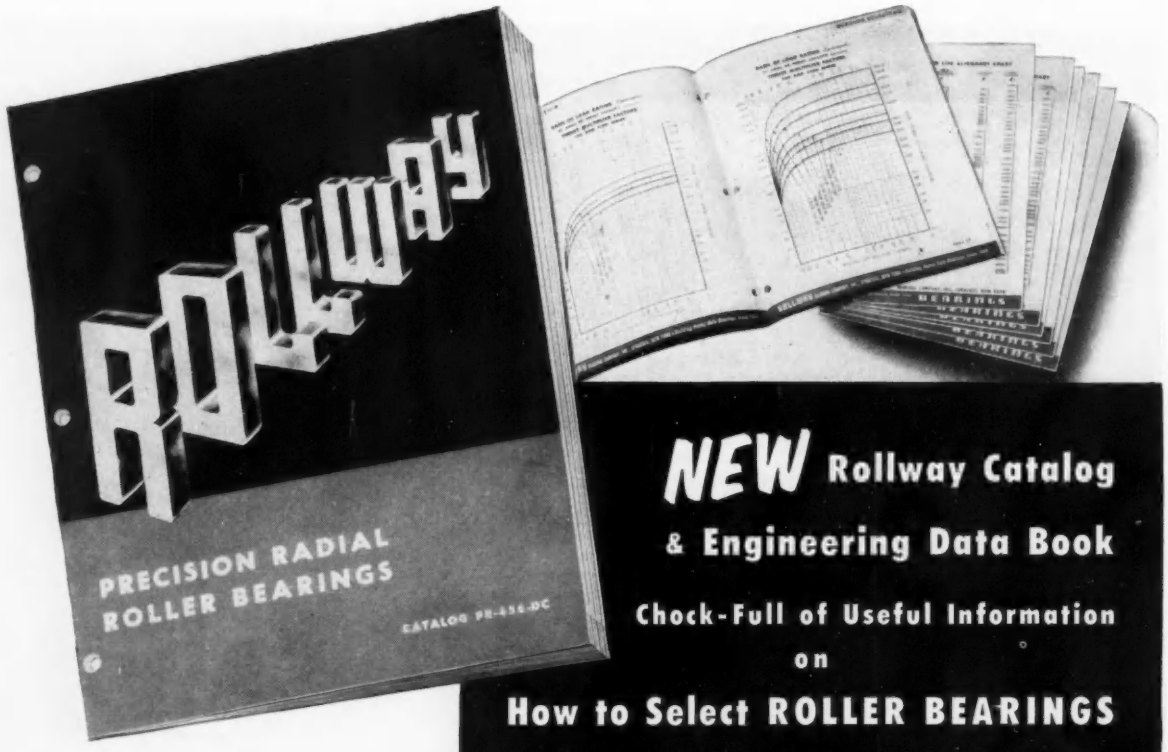
Fact is that today, eighteen out of the twenty-two automotive manufaeturers using timing chains, actually *specify* Morse Chain Drives as original equipment.

More than 60,000,000 of these drives have already gone into cars, trucks, and buses—giving vehicle owners long service life, plus freedom from maintenance worries. Morse Timing Chains operate safely, quietly, and smoothly—with positive timing.

Investigate Morse Timing Chain Drives . . . and the other precision-built power transmission products which Morse manufactures. We have expert engineers always available to help you in your power transmission requirements. Write, wire, or phone us, today, for quick assistance on your particular problem.

MORSE CHAIN COMPANY: DETROIT, MICHIGAN; ITHACA, NEW YORK.

MORSE MORSE BW *trademark **POWER TRANSMISSION PRODUCTS**



NEW Rollway Catalog & Engineering Data Book

Chock-Full of Useful Information on How to Select ROLLER BEARINGS

- **Reflects latest RBEC* standards and formulas, PLUS the latest research of Rollway engineers.**
- **Contains the following important data on precision radial roller bearings . . .**

CAPACITIES Detailed information on radial static capacities, radial dynamic capacities, and thrust capacities of cylindrical radial bearings.

Thrust capacities and radial dynamic capacities are given separately. Thrust load does *not* reduce radial capacity nor life expectancy of bearing: It is not necessary to calculate an "Equivalent Radial Load."

APPLICATIONS Load ratings, radial internal clearances temperature allowances, provision for float, alignments, seals, lubrication, etc. . . . all are thoroughly covered, supplemented by engineering drawings of typical applications.

NOMOGRAMS The RBEC* formula is here converted into simple nomogram charts, eliminating complicated selection procedures. You can find in seconds the proper bearing for your application.

PRECISION TABLES Detailed data shows the tolerances achieved with varying degrees of precision. Complete tables include limits for shaft diameters and housing bores to obtain proper type of fit of inner and outer races for various operating conditions.

*Roller Bearing Engineers' Comm.—Anti-Friction Bearing Mfrs. Assn.

Send for Your **FREE** *Copy Today!*

Included with the new Rollway handbook-catalog are extra copies of the nomogram charts. Send for yours today!

ROLLWAY BEARING CO., INC. 541 Seymour St. Syracuse 4, N. Y.

Please send free copy of your new handbook-catalog with extra nomogram charts.

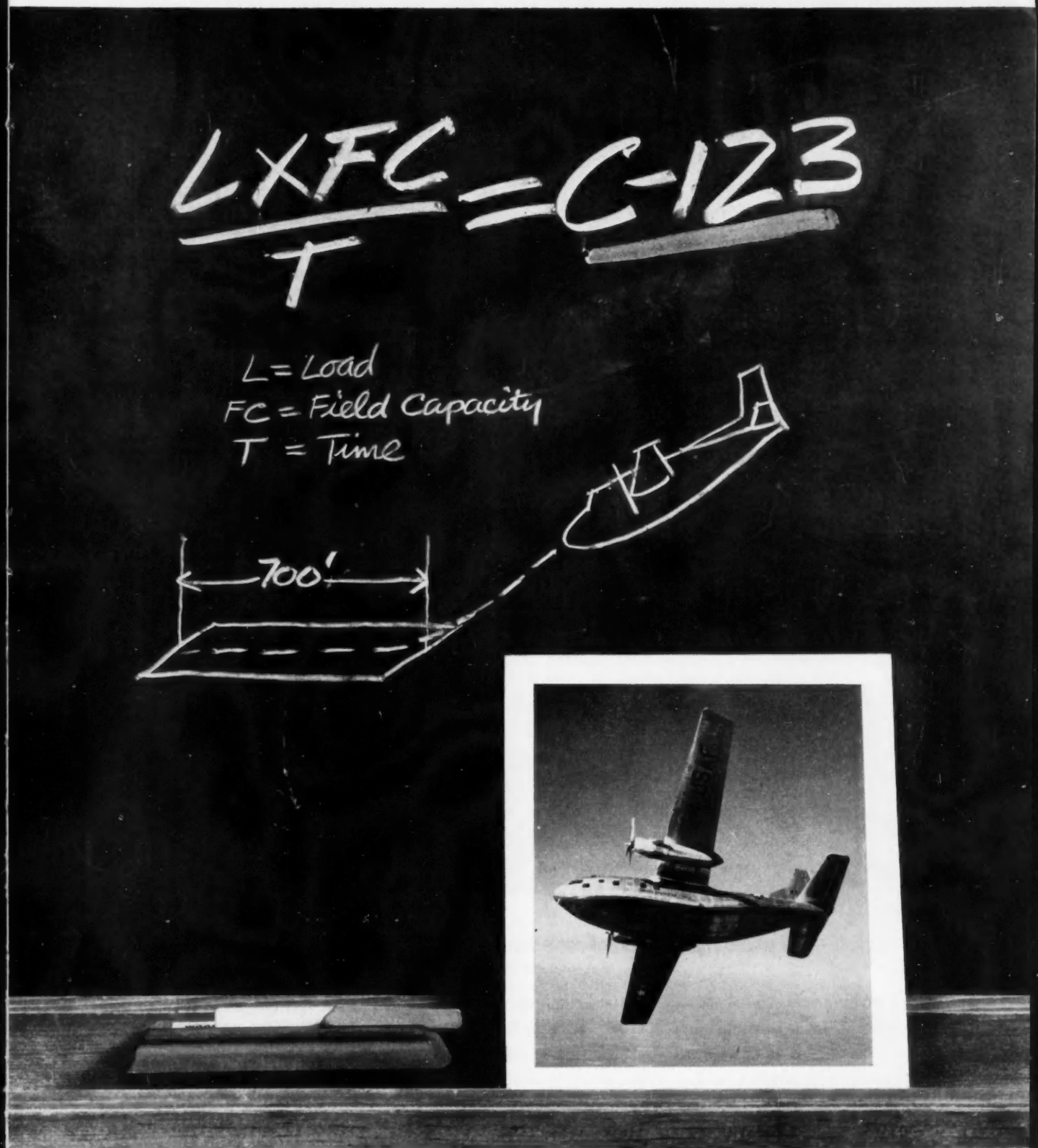
Name_____ Title_____

Firm Name_____

Address_____

City_____ Zone____ State_____

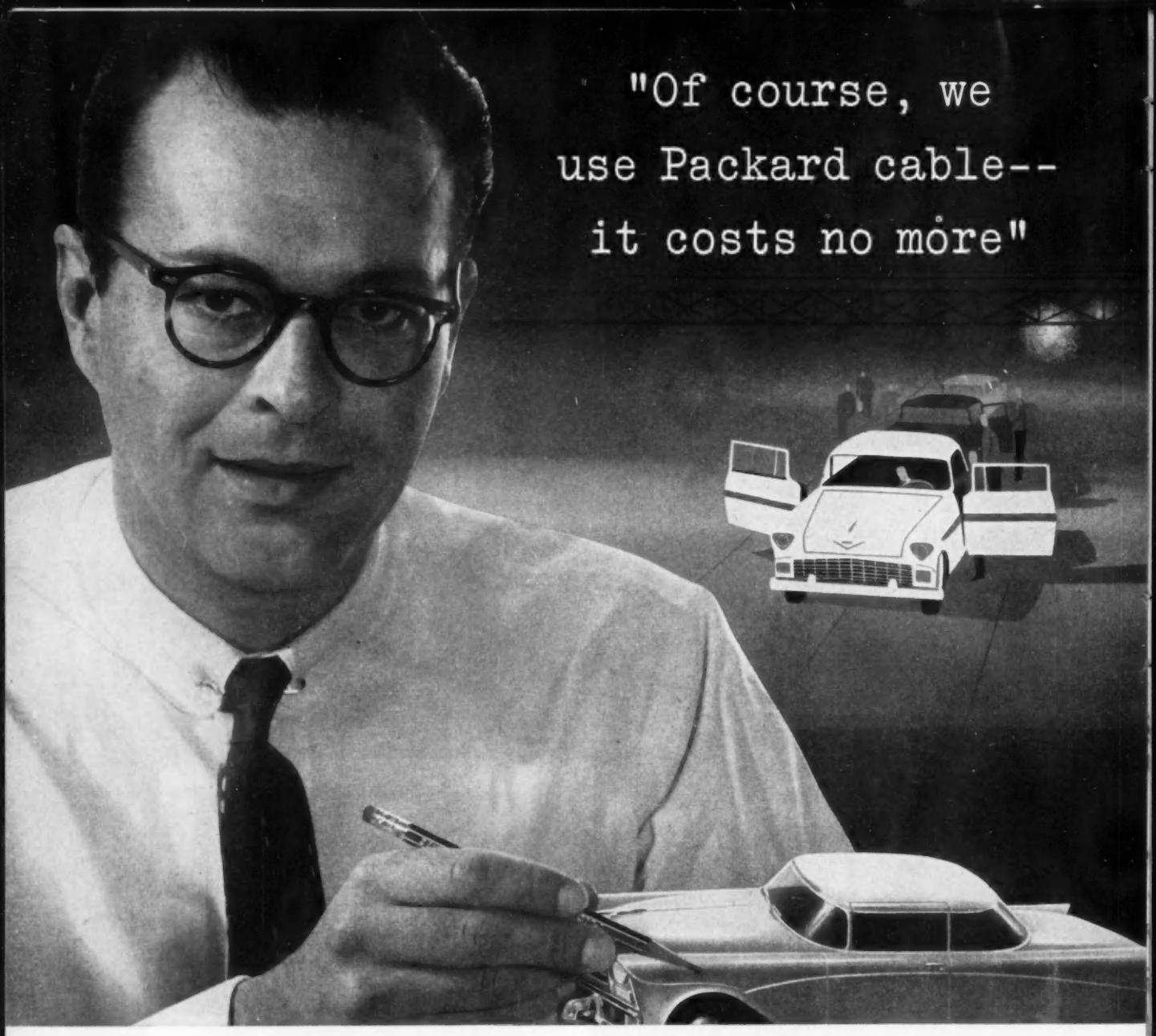
ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco



Battle Situation: 10 105mm howitzers, with ammunition and gun crews, plus 10 bulldozers and operators must be delivered to an enemy-surrounded field.
Field conditions: Ungraded field, sandy and eroded; 1000 ft. at its widest dimension. Assume 15 mph velocity wind. Troops must be ground landed.
Solution: Load 20 Fairchild C-123 assault transports at supply center 450 miles away; take 3 hours to fly to destination. Land your airplanes 8 seconds apart—allow 700 ft. ground roll for each.
Theorem: Fairchild C-123 rugged performance and reliability is proved daily in stateside assault and overseas logistical missions.

FAIRCHILD
AIRCRAFT DIVISION • HAGERSTOWN 10, MARYLAND
A Division of Fairchild Engine and Airplane Corporation

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!



Built to last—and priced right—Packard cable leads all others combined in preference and in sales

WHY TAKE CHANCES on cable troubles when it costs no more to specify the *best* in automotive cable and cable assemblies from Packard Electric. Here at Packard we have specialized for years in the development of tough insulation for all types of automotive cable—insulation so tough that it resists abrasion and chafing and cuts down the likelihood of electrical failure.

SPILLED FUEL, OIL OR HYDRAULIC FLUID, TEMPERATURE EXTREMES, EXPOSED INSTALLATIONS . . . whatever the problem, Packard has a cable to meet the conditions while delivering consistent, satisfactory performance. These are some of the important reasons why Packard cable is original equipment on more cars and trucks than all other brands combined!

OUR ENGINEERS ARE AT YOUR SERVICE—ready to help design new components, if necessary, to solve a particular cable problem. It's another service to Packard customers. Why not take advantage of it today?

GM GENERAL MOTORS

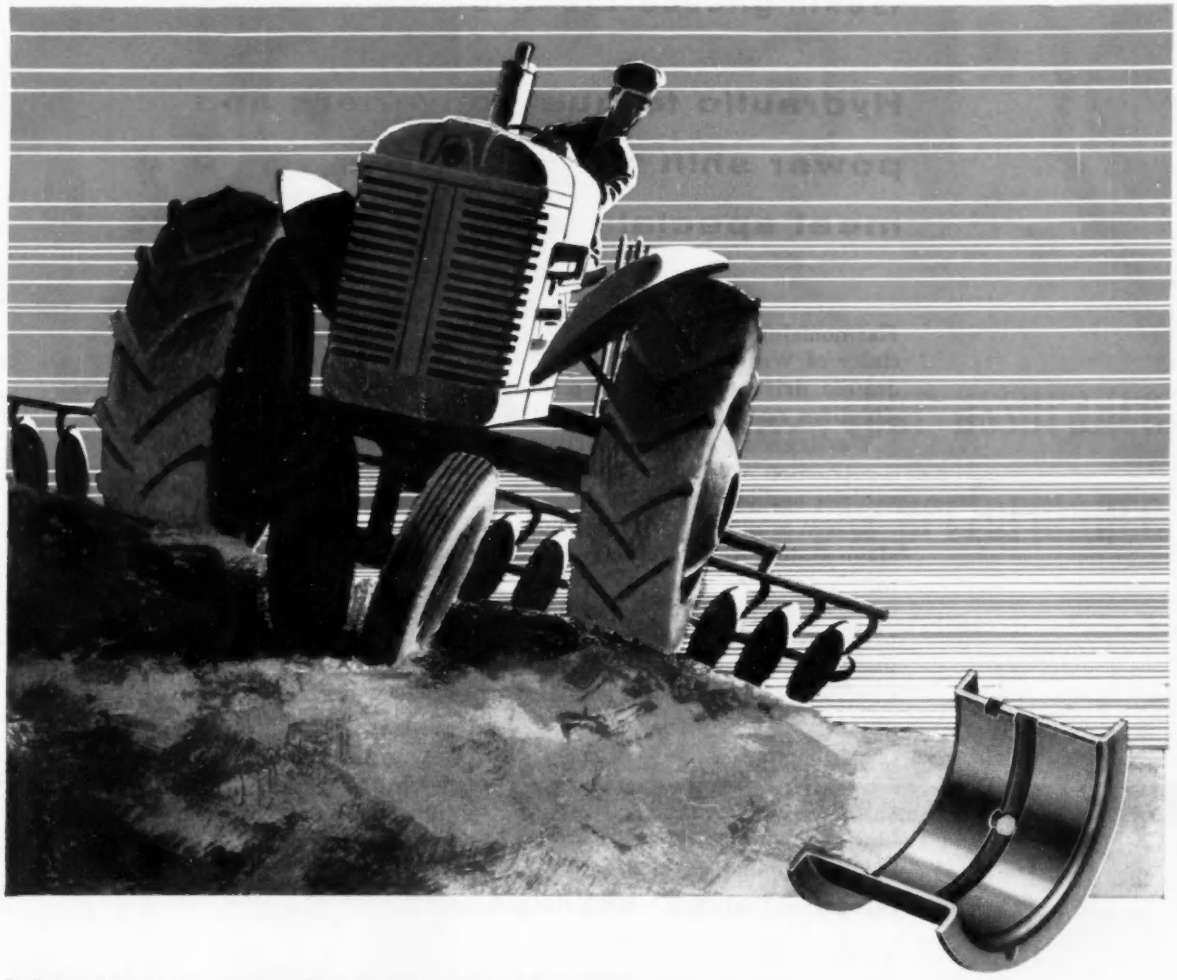
Packard

REG. U.S. PAT. OFF.

Offices in Detroit, Chicago, and Oakland, California

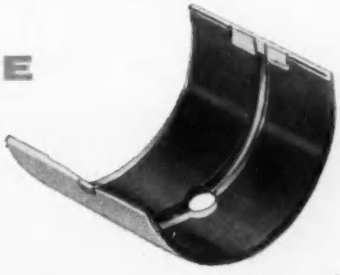
Packard Electric Division
General Motors, Warren, Ohio

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING



his first requirement is . . .

DEPENDABLE PERFORMANCE



Ingenious mechanical equipment has solved the labor problem for today's farmer. But his first requirement of any unit is dependability of operation—around the clock if need be—in his constant battle with nature. Federal-Mogul bearings have been assuring dependability in farm tractors and implements for generations. The same dependability characterizes Federal-Mogul bearings in any application, from automobiles to construction equipment—dependability that is the product of over 50 years' highly specialized bearing manufacture.

FEDERAL-MOGUL DIVISION

FEDERAL Mogul

SINCE 1899

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11035 SHOEMAKER, DETROIT 13, MICHIGAN

Westinghouse Electric Corporation

Hydraulic torque converters and power shift transmissions meet specialized equipment needs

Harmonizing engine characteristics with your drive problems is a specialty of Westinghouse hydraulic drives engineering. The result is a hydraulic drive that assures maximum *work output* of your equipment, simplifies operator training, and reduces maintenance.

Westinghouse hydraulic drives are currently being used on heavy-duty construction equipment, off-highway trucks, special-purpose military vehicles and oil well servicing rigs.

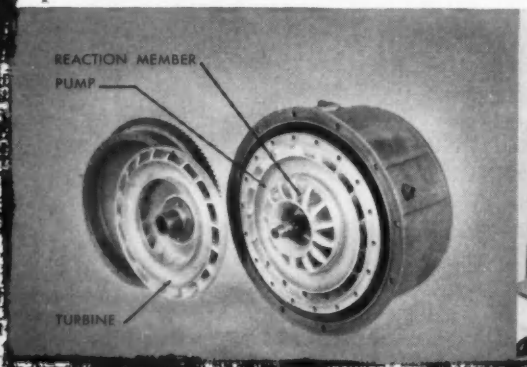
The Westinghouse torque converter is based on the Schneider single-stage system which provides highest efficiency over an extended operating range.

Because Westinghouse manufactures drive components, and not end products, you are assured complete confidence on your advanced design planning. For more information write Westinghouse Electric Corporation, Gearing Division, Pittsburgh 1, Pennsylvania. J-07353

Developed to meet your special needs in earth moving, construction and materials-handling equipment.

(1) Westinghouse single-stage torque converter showing simplicity of basic parts. (2) Matching equipment requirements, Westinghouse engineers analyze advance design planning; result (3), a typical Westinghouse torque converter — power shift transmission package.

1



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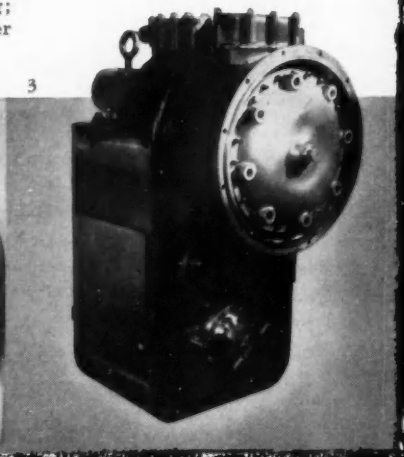


WATCH WESTINGHOUSE!

COVER THE PRESIDENTIAL CAMPAIGN ON CBS TELEVISION AND RADIO!

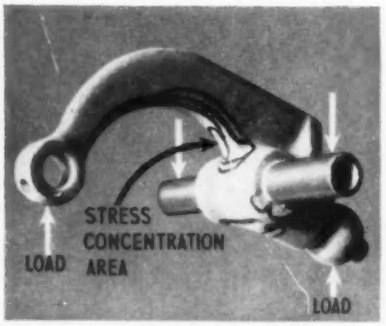
* B-N.....your assurance of finer piston pin performance

The Burgess-Norton insignia symbolizes
the engineering and production skill that guarantees
better performance for industry.
Throughout the years
the engineering, metallurgy and production facilities
at Burgess-Norton have kept pace
with the ever-increasing demands for quality parts.
Ability to meet these requirements as to
production and quality has made Burgess-Norton
the world's largest independent producer of piston pins.
Burgess-Norton is proud of its position . . .
and with it accepts the responsibility
to maintain constant vigilance in quality control,
and makes available to industry the latest
in manufacturing facilities and methods.

A part is made right only when it is satisfactory to our customer

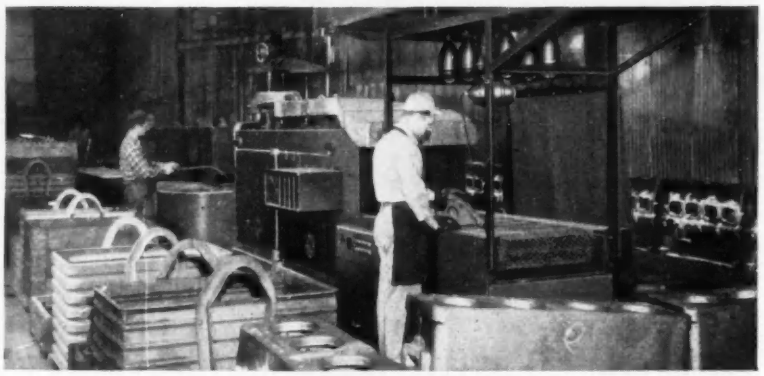
Burgess Norton Mfg. Co.
GENEVA, ILLINOIS

SERVING INDUSTRY FOR OVER FIFTY YEARS



STRESSCOAT IMPROVES CASTING DESIGN—This Magnaflux developed brittle lacquer coating is used for testing and measuring stress in working parts or designs. Stress analysis is providing new ways to reduce cost and weight of products to make them lighter, stronger and cheaper.

Case Studies:
NONDESTRUCTIVE TESTING SYSTEMS



Custom testing installation for malleable castings.

New Methods Increase Profits and Expand the Market for Castings—Help Improve Foundry Practices

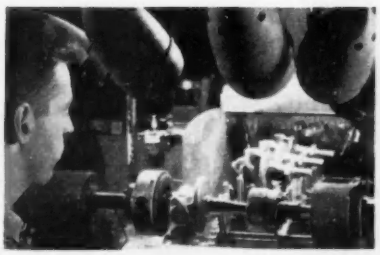
MAGNATEST SORTS CONTAMINATED CASTINGS by using their conductivity to measure purity. A small hand held coil induces eddy currents in parts which in turn registers on the dial. By observing changes in this current you can determine the degree of contamination. 10,000 red brass castings were recently sorted by this means at a rate of 500 per hour.

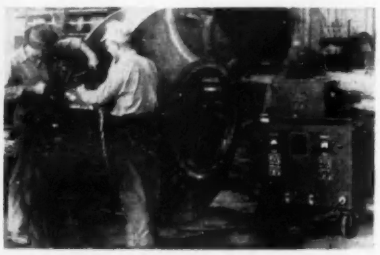
In today's economy, the profit-minded foundryman strives for consistent quality rather than perfection. This consistency pays off for both the foundryman and user.

Magnaflux offers a variety of nondestructive testing methods to aid you in achieving consistent quality in day-to-day foundry production. For instance, consistent quality starts with good casting design. Ⓜ Stresscoat is invaluable for measuring stress and load concentrations, to develop designs for light, stronger and cheaper cast parts.

Magnaglo tests on pilot runs can indicate troublesome pouring or handling practices which may contribute to cracks and other defects in finished parts. With Magnaflux, Magnaglo or Zyglo methods all severe cracks in any metal can be found and evaluated. Thus, you eliminate scrapping of good castings for seemingly visible defects that have no bearing upon the true strength or service life of the casting. If serious defects do exist, proper corrective action can be taken before further costly processing. For any selected service level, Ⓜ test systems permit you to set the standards and hold to them. After correct procedures have once been established, only a sampling "finger-on-the-pulse" inspection is required to insure consistent, reliable casting production. These are profitable steps to building acceptance and expanding marketing opportunities for cast parts.

For detailed information on Ⓜ applications for your specific operation, call in one of our experienced Magnaflux engineers, or write today.





FOOLPROOF METHODS FOR LARGE OR SMALL CASTINGS

Ⓜ offers a variety of fast, low cost, nondestructive methods for testing ferrous and non-ferrous castings of every size and shape from watch cases to valves or side frames. Whether you require a custom installation for steady production-line operation, or a portable unit for sampling tests in your production process, we can supply systems to meet your exact needs.

HALLMARK OF QUALITY IN NONDESTRUCTIVE TEST SYSTEMS

MAGNAFLUX CORPORATION

Write for complete details concerning any of the above case studies, (excerpts from MAGNAFACTS), or ask for our new booklet on Lower Manufacturing Costs.

Take Your Inspection Problems to the House of Answers . . .

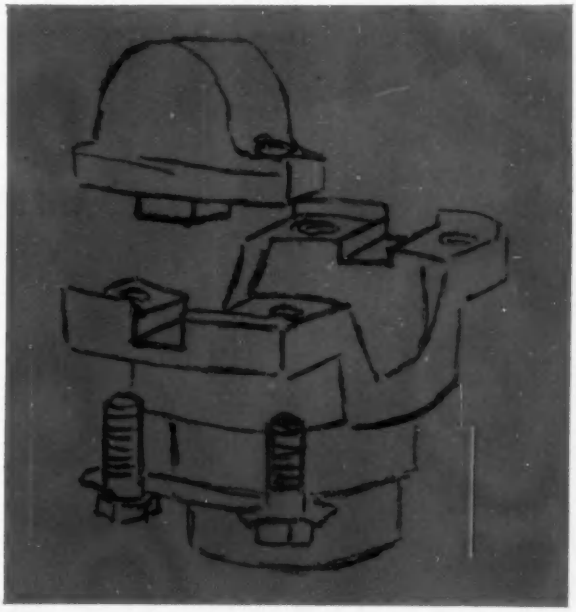
MAGNAFLUX CORPORATION

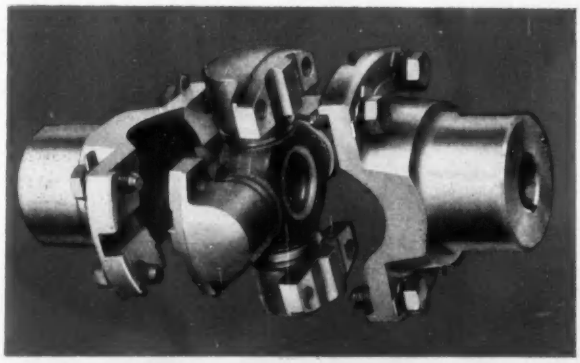
7348 W. Lawrence Avenue • Chicago 31, Illinois

New York 36 • Pittsburgh 36 • Cleveland 15 • Detroit 11 • Dallas 19 • Los Angeles 58

SPECIFY KEY-DRIVE JOINTS FOR **FAST** ASSEMBLY AND SERVICE OPERATIONS

Unique features of MECHANICS Roller Bearing UNIVERSAL JOINTS make them unusually easy to install and service. The complete cross and bearing assembly can be removed simply by taking out the cap screws and separating the end yokes slightly. No flange is required for drive shaft connections. Accurately and durably built for long, heavy service, MECHANICS Roller Bearing UNIVERSAL JOINTS are inherently balanced for smooth operation.





Let our engineers show you how MECHANICS close-coupled Roller Bearing UNIVERSAL JOINTS conserve space and compensate for offset shafts, in your new and improved models.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
36 So. Wabash, Chicago 3, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

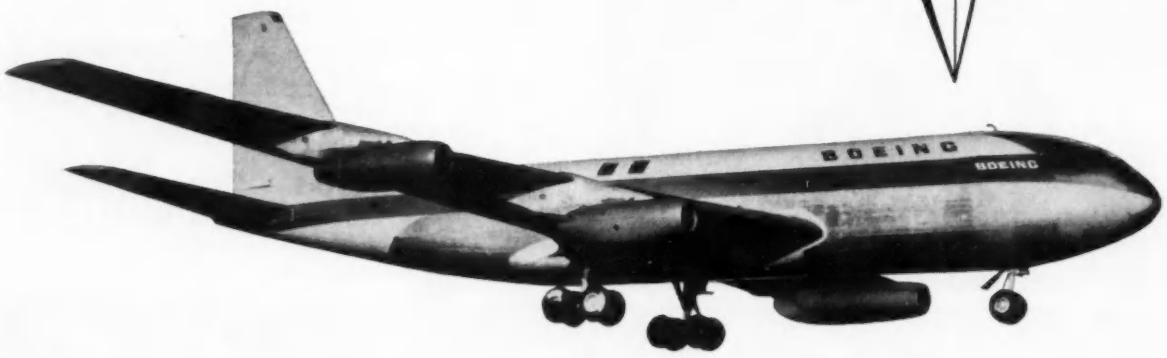
WHETHER

YOU

FLY

THE

BOEING 707.....



.....OR THE

DOUGLAS DC-8.... *you'll take off and land on CPT landing gear*

Out of CPT's 30-year experience came the engineering and drawings for the landing gears for both these American all-jet intercontinental transports.

And out of CPT's giant precision manufacturing facilities are coming the landing-gear ship-sets to speed the day when fleets of DC-8's and 707's will fly on scheduled flights.

Put CPT's wealth of experience and facilities to work now on your projects of Tomorrow. No other landing-gear builder has CPT's combination of experience, knowledge, and facilities.

ENGINEERS: If you would like to work at CPT on airframe-component design problems, write us. Liberal profit-sharing and retirement plan, modern plant and facilities.

CPT

CLEVELAND PNEUMATIC TOOL CO.

3781 East 77th Street • Cleveland 5, Ohio

Sales-engineering offices in
Seattle, Los Angeles, Fort Worth-Dallas and Levittown, L.I.

a message for Pesco's western friends:

new faces, new facilities

will mean better, faster service on Pesco products

To provide improved customer service in the nine western states, Pesco has established –

SALES OFFICES IN LOS ANGELES AND SEATTLE

These direct factory representatives are now available to provide technical assistance on your accessory problems. They are backed up by the engineering skills and technological resources of the entire Pesco organization.

● **R. B. Harlan, Jr.**
Western Regional Manager
Los Angeles — STanley 7-3148

● **Harold S. Doelcher**
Service Center Manager

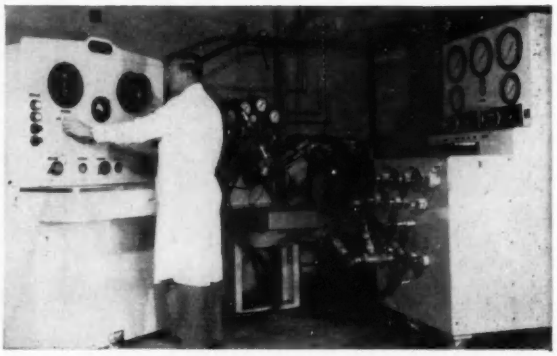
● **R. H. Collier**
Sales Engineer
Seattle — MAin 8442

● **F. C. Morris**
Senior Sales Engineer
Los Angeles — STanley 7-3148

PESCO PACIFIC SERVICE CENTER

5521 Cleon Ave., North Hollywood, Calif.

This plant is a completely equipped facility for the testing and overhaul of all Pesco products—aircraft and industrial. It is operating under Air Force cognizance and with Navy and Civil Aeronautics Administration approval.



Technician runs dynamometer test on fuel pumps in explosion-proof test cell.

Pesco fuel and hydraulic pumps being overhauled in modern repair department.

For information or service on Pesco products, our western customers are invited to make use of these new facilities.

Pesco Configuration Production

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

Producing the Best in Hydraulic Pumps, Fuel Pumps, Electric Motors and Axial Flow Blowers

BW BORG-WARNER TRADEMARK

XVII

This is the seventeenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Uses of Aluminum in Alloy Steels

Aluminum as an element has been known to chemists and metallurgists for many years. It is never found in nature in its metallic state, being derived chiefly from bauxite, an aluminum hydroxide. Bauxite is present in various parts of the world, including several tropical and semi-tropical regions.

When used in the making of alloy steels, aluminum has several important functions. Because of its great affinity for oxygen, it is a reliable deoxidizer. It produces fine austenitic grain size. And when it is present in amounts of approximately 1 pct, it promotes nitriding. The nitriding process could be described as surface- or case-hardening by means of a nitrogenous medium, or by heating in an atmosphere of ammonia gas and dissociated ammonia mixed in proper proportions.

Other effective agents in producing nitrided cases are chromium, vanadium, tungsten, and molybdenum. As a rule, however, the hardest cases are obtained with aluminum-bearing steels, the nitriding grades being a good example. These are usually steels of medium carbon content with additions of chromium, molybdenum, and sometimes nickel.

Generally speaking, the lower the effective nitriding temperature, the harder the case will be. Aluminum-bearing steels usually show a case-hardness range of 950 to 1150 DPHN (diamond pyramid hardness number). Steels in which no aluminum is present have cases of substantially lower hardness.

If you would care to know more about aluminum as an addition or alloying agent in steels, Bethlehem metallurgists will gladly give you full information. Just write or call us; our technicians are always at your service. They will do everything possible to help make your problems easier. And whenever you need new supplies of alloy steels, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through XVI inclusive, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 16 topics are now available in a convenient 32-page booklet, "Quick Facts About Alloy Steels," and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

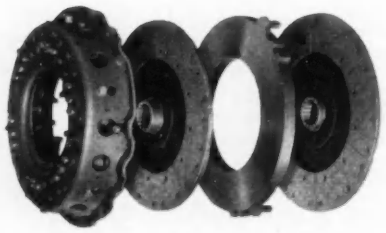
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

New equipment, expanded departments, added technical personnel and increased productivity all help to make Long your ideal "production partner."

But you'll discover Long's real plus factors in our management-engineering team. Its talent for creating high quality products with economical design and volume manufacturing advantages is your biggest profit potential.



DOUBLE-PLATE CLUTCHES BOOST TORQUE CAPACITY

Available in many sizes, Long's double-plate clutches with high-gripping action anticipate advancing horsepower and torque requirements in trucks, tractors, off-highway vehicles and industrial applications. Like Long single-plate clutches, these heavy-duty production models are individually tailored by our engineers to performance requirements of any size or type of vehicle.

Long-innovated clutch features that have set industry standards include dry discs, variable springing, high-ventilation triangular covers, spring vibration dampers and cushion segments. Ask us to recommend an application conforming to your specifications.

LONG B-W BORG-WARNER

LONG®

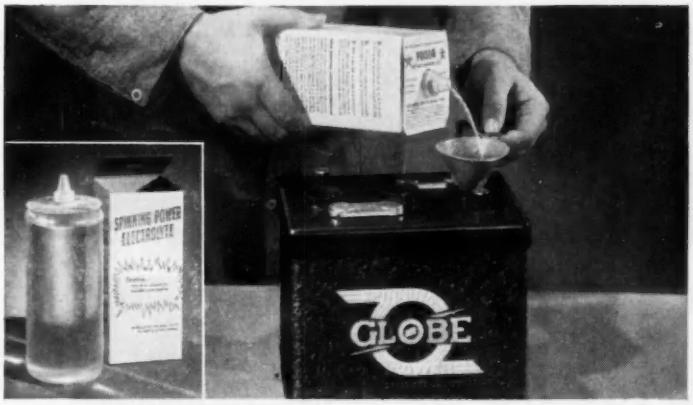
LONG MANUFACTURING DIVISION, BORG-WARNER CORPORATION
12501 DeQuindre Street, Detroit 12, Michigan
Also: Oakville, Ontario, Canada
Export Sales: Borg-Warner International, 36 South Wabash St., Chicago 3, Illinois

THE STANDARD OF QUALITY AND PERFORMANCE SINCE 1903

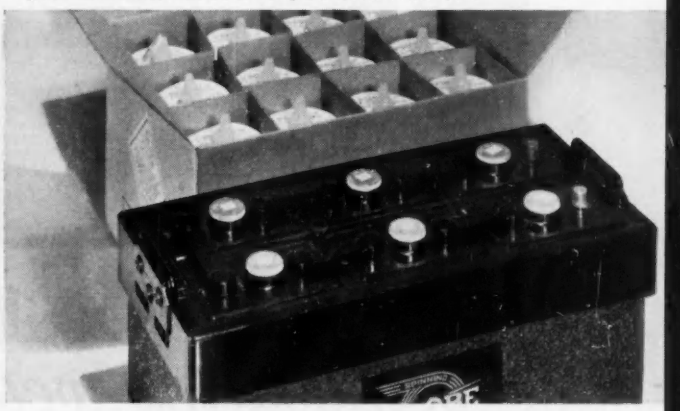
New GLOBE dry-charged puts battery sales in high gear

SALES STIMULATING . . . EFFICIENT . . . ALL-IN-ONE PACKAGING promotes displays, simplifies stocking. Everything needed — battery, electrolyte and pouring holder — is contained in this single, compact package.

NOW YOU CAN CARRY A COMPLETE INVENTORY, meet the needs of any vehicle on the road. There's no standing loss or need for annoying trickle charge. Globe dry-charged batteries protect your investment because they're fresh until sold.



SAFE AND ECONOMICAL TO SHIP AND HANDLE. *Safe* sturdy plastic bottle has great resistance to shock or impact. Cardboard bottle holder assures positive grip. *Economical* — 15 plastic bottles weigh less than one glass bottle, cost less to ship, take less time to handle. Disposable bottles eliminate returns. No money tied up in returnable or carboy inventory.



FOR ADDED CONVENIENCE WITH LARGER-SIZED BATTERIES and to comply with ICC regulations, certain batteries and electrolyte are shipped in separate cartons. Spinning Power electrolyte is packaged in plastic bottles offering the same benefits as those shown previously. Exact specific gravity and acid purity are assured through Globe's quality controls.

Get Fast, Low-Cost Delivery, Too!

Thirteen of Globe's 16 battery plants,* below, are equipped for dry-charged battery and Spinning Power electrolyte production. Their strategic locations put approximately 40% of the automotive market within a 50¢ per cwt truck load freight zone. For all your battery and electrolyte needs, call on Globe to be sure of top-notch sales and performance.

GLOBE-UNION INC.

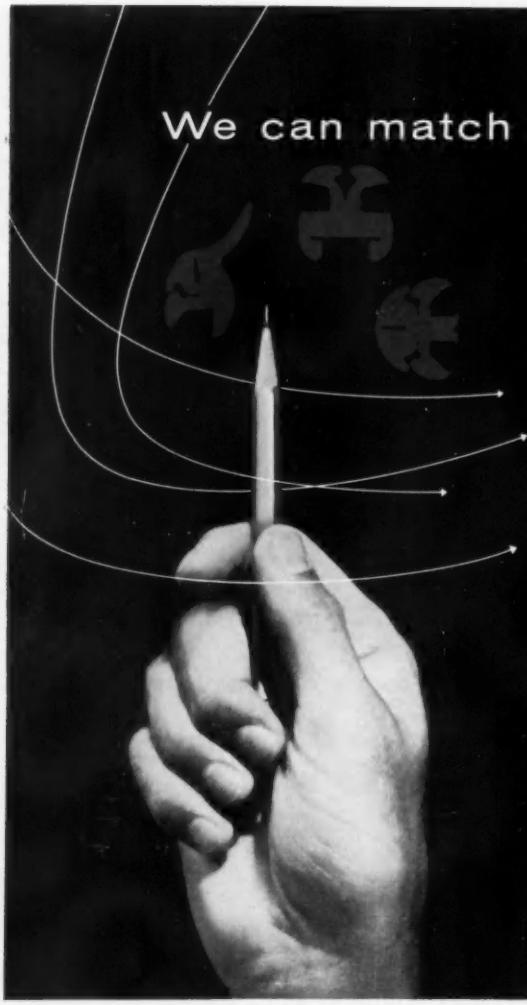
MILWAUKEE 1, WISCONSIN

Battery plants at: *HOUSTON, TEXAS *MEMPHIS, TENNESSEE *ATLANTA, GEORGIA *DALLAS, TEXAS *MEDFORD, MASSACHUSETTS *MILWAUKEE, WISCONSIN *MINERAL RIDGE, OHIO *PHILADELPHIA, PENNSYLVANIA *EMPORIA, KANSAS *REIDSVILLE, N. CAROLINA *SAN JOSE, CALIFORNIA *LOUISVILLE, KENTUCKY *HASTINGS-ON-HUDSON, NEW YORK—LOS ANGELES, CALIFORNIA—OREGON CITY, OREGON—AJAX, (ONTARIO) CANADA

If it's Petroleum-powered there's a GLOBE-BUILT BATTERY right from the start!

We can match any DESIGN

with Inland Self-Sealing Weather Strip

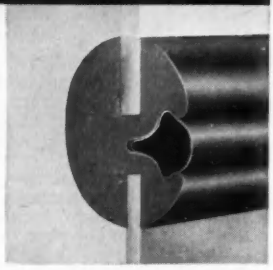


No matter what your sealing problem is, or will be—whether in glass or plastic; flat or curved; fixed or sliding window—Inland Self-Sealing Weather Strip, with separate patented filler strip, will solve it. And when Inland Strip goes in, water stays out! In cars, trucks, buses, trains, planes and other over-the-road vehicles and in any structures where windows are fixed and must be positively sealed—Inland Weather Strip is the answer!

Inland Self-Sealing Weather Strip can be produced to meet your individual requirements, and is always available in many standard shapes and sizes.

When you specify Inland Weather Strip you can be sure it will be precision made and you are also assured of a long, trouble-free service life.

INLAND
self-sealing weather strip
(PATENTED)



INLAND MANUFACTURING DIVISION
General Motors Corporation, Dayton, Ohio

a part of the General Motors Master Plan for Greater Highway Safety through Better Engineered Products!

Whatever the **DESIGN...**

We can make it **WATER-TIGHT!**

Transportation Industry

Automotive Installations

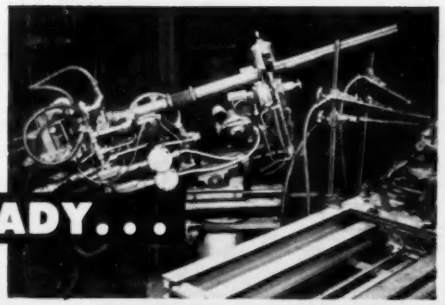
Railway Equipment

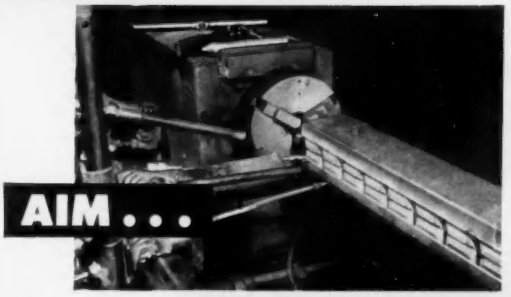
Marine Applications

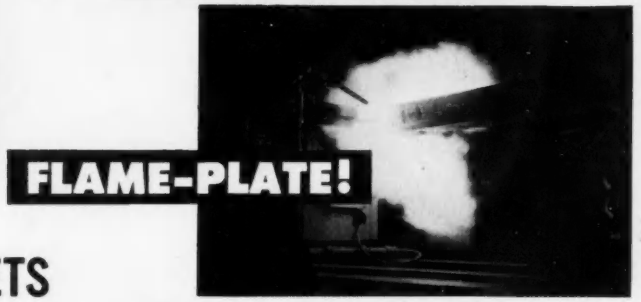
Over-the-road Equipment

Commercial Structures

LINDE's Flame-Plating gun is operated entirely by remote control. At control panel (below) is operator, who observes process through safety-glass window. At right, Flame-Plating gun is seen as workpiece is secured in fixture (top), as gun is brought into range (center), and at the instant of a blast in the plating action (bottom).







Not all guns shoot BULLETS ...this one gives metal parts EXTRA WEAR RESISTANCE

A dramatic and useful coating process for metal parts has been developed by LINDE engineers to provide extra resistance to wear and abrasion. This method, called Flame-Plating, utilizes a special, rapid-fire gun to apply an extremely hard coating of tungsten carbide or aluminum oxide on precision parts subject to unusual wear or fretting corrosion.

The Flame-Plating gun consists of a barrel and a mechanism for loading precise amounts of powdered coating material and explosive gases into a firing chamber. The powder—tungsten carbide or aluminum oxide—remains suspended in the gases until a controlled spark ignites the mixture.

The resulting detonation creates heat and pressure waves of tremendous force. These waves rip through the gas-and-powder mixture at supersonic velocity. The particles are hurled against the work with terrific impact. They fuse together and build up until the desired thickness is obtained.

The temperature of the workpiece seldom exceeds 400 degrees F. Thus precision parts can be Flame-Plated without risk of changes in physical dimensions or metallurgical properties. Coatings can be Flame-Plated in thicknesses from .002 to .010 inch, and finished to 0.5 microinches rms. Practically all metals can be Flame-Plated.

The extra resistance of Flame-Plated parts to wear, abrasion, and fretting corrosion has been proved in actual service. Vital parts in aircraft and automotive power plants, hydraulic systems, and heating units, as well as textile and canning machinery, plug and ring gages, bearings, and seals have all had their useful life greatly extended—and economically, too—with Flame-Plating by LINDE. Find out how Flame-Plating can help you improve your own design. Write for a free copy of the booklet, "Flame-Plating," F8065. Address "Flame-Plating, Department SA-9."

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, New York

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a trade-mark and FPL is a service-mark of Union Carbide and Carbon Corporation.

Flame-Plating by Linde

FOR THE GIANT JETS...

scores of precision components

Through many years Kelsey-Hayes has worked closely with major aircraft engine builders. Today, with the addition of new plants, expanded research and engineering staffs, and augmented production facilities, assignments from the aviation industry are increasing rapidly.

Products include accessory gear assemblies, actuators, transmissions, power recovery units, radar tracking and scanning equipment, computers and controls. And for jets: compressor rotors, turbine sections, blades, buckets, vanes.

Kelsey-Hayes has the experience and facilities for research, design, prototype development and production.

KELSEY-HAYES

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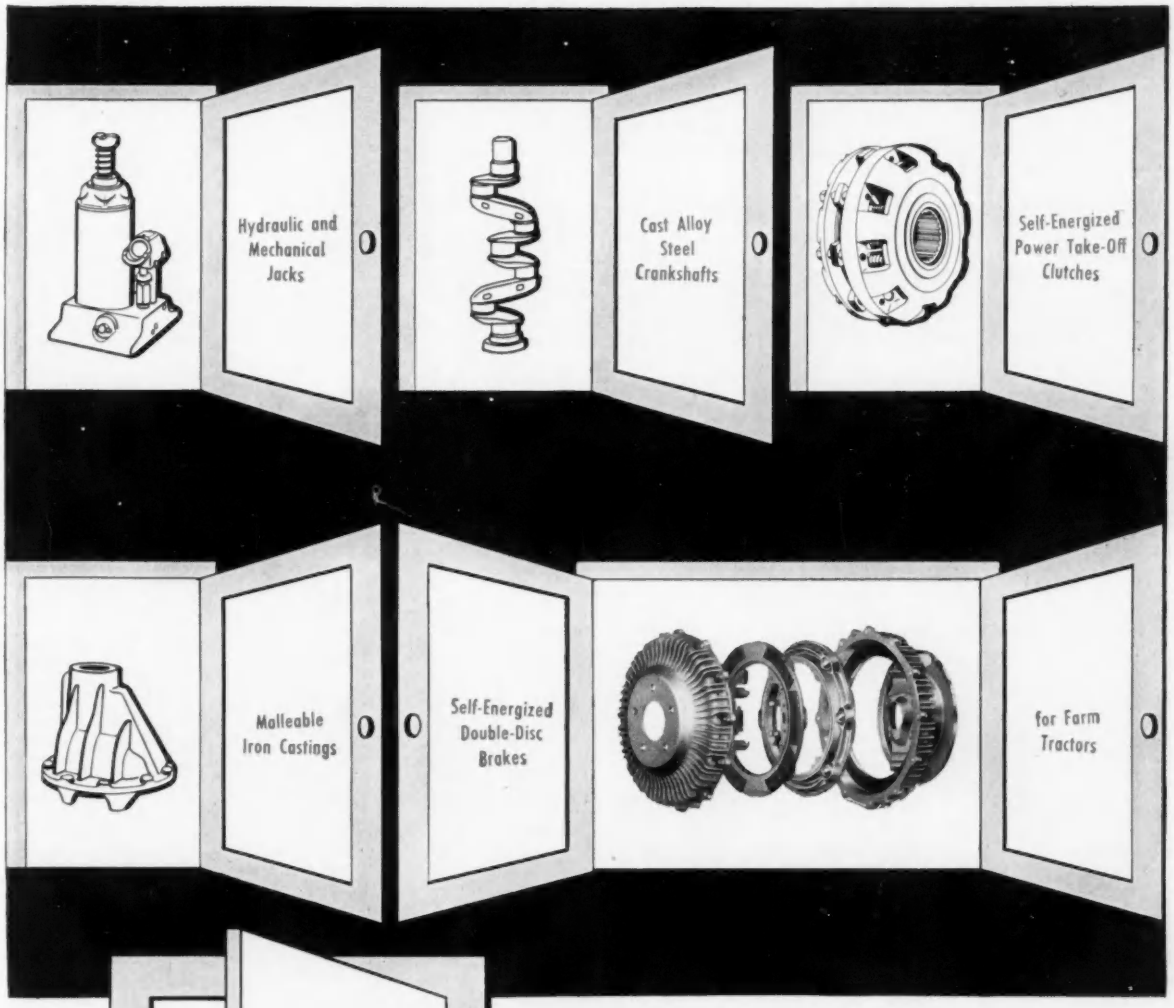
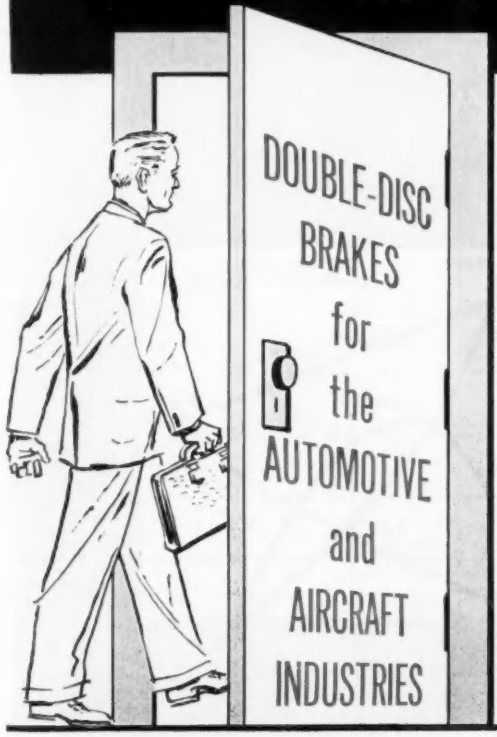
14 PLANTS / Detroit and Jackson, Michigan; McKeesport, Pa.; Los Angeles, Calif.; Windsor, Ontario, Canada • Davenport, Iowa (French & Hecht Farm Implement and Wheel Division) • Springfield, Ohio (SPECO Aviation, Electronics and Machine Tool Division) Utica, New York—4 plants—(Utica Drop Forge and Tool Corporation, a subsidiary)





For 48 years now we have been opening doors into new fields by working closely with our customers. Today, we are ready, willing and more able than ever to accept new challenges. We can be of help to you in solving your manufacturing problems. You will find our vast production facilities and engineering talent always at your service.

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SAINT JOSEPH, MICHIGAN

Plants also at Benton Harbor and Hartford, Michigan
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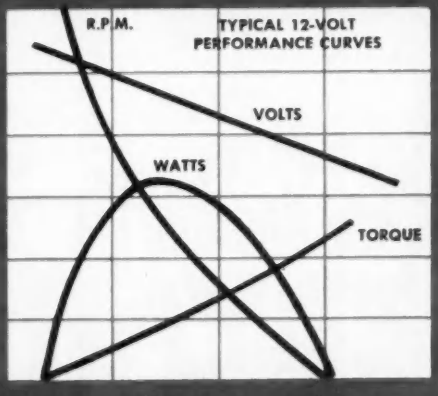
Manufacturing for the automotive & farm machinery industries since 1908

PROGRESSIVE ENGINEERING MAKES THE DIFFERENCE

TYPICAL SPECIFICATIONS	MODEL 1113501	MODEL 1113551
VOLTS	6	12
FRAME DIAMETER (INCHES)	3	3
FRAME LENGTH (INCHES)	4.30	4.42
MOUNTED LENGTH (INCHES)	5.25	5.37
APPROXIMATE WEIGHT (POUNDS)	6.5	6.5



DELCO-REMY DEVELOPS A NEW LINE OF CRANKING MOTORS FOR OUTBOARDS AND OTHER APPLICATIONS

A new series of Delco-Remy cranking motors, with many new design features, is now available for outboards, garden tractors, power mowers and other similar applications.

With a frame diameter of only 3 inches, an overall length of slightly over 5 inches when mounted, and a weight of about 6½ pounds, the powerful new motors will crank one-cylinder engines up to 15 H.P., two-cylinder engines up to 35 H.P., and four-cylinder engines of even higher horsepower.

These four-pole, four-field motors, designed for both 6-volt and 12-volt systems, may be powered by standard Delco batteries.

Available now for original equipment applications, the new motors can be supplied with or without automatic drives and solenoid switches to meet varying requirements. They are yet another example of Delco-Remy leadership in electrical equipment "Wherever Wheels Turn or Propellers Spin." Manufacturers of engines and power equipment are invited to write directly to Delco-Remy for complete information and engineering assistance on the application of these units.

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY STARTING WITH

Delco-Remy

ELECTRICAL SYSTEMS

SELECT CALIFORNIA ENGINEERING GROUP EXPLORES THERMODYNAMIC CYCLES IN ADVANCED ENGINES

A Few Positions Still Open For Cycle Analysis . . . Thermodynamics . . . and Nuclear Engineers.

Propulsion experts at North American Aviation, Los Angeles Division are carrying out thermodynamic analyses of highly advanced engines at the company's Los Angeles, California plant. The studies include investigation of turbojets, ramjets, rockets and nuclear propulsion devices . . . compressors, combustors, turbines, afterburners, exhaust nozzles and thrust augmentation devices.

The Engineering Personnel Department at North American's Los Angeles Division, Engineering Department is seeking several qualified engineers who are interested in this work. They are looking for men who have had a minimum of three years thermo-dynamics cycle analysis experience with jet engines or propulsion analysis. Advanced degrees are preferred, though not required.

Interested engineers are invited to contact Mr. W. H. Nance, Department 56 SAE, Los Angeles Division Engr. Dept., North American Aviation, Inc., International Airport, Los Angeles 45, California.

ENGINEERS

CONTROLS ENGINEERS are KEY MEN

A most important element of engine design is harnessing the power to bring the aircraft home safely. This puts a Controls Engineer in a key spot.

Now unique opportunities exist for talented men to develop controls for new product line of advanced small turboshaft, turboprop and turbojet engines.

In: ENGINE CONTROLS DEVELOPMENT

SYSTEMS DESIGN: responsibility design and develop advanced systems—performance requirements—schematic diagrams—component and test specifications.

COMPONENT DESIGN: design, develop and package specific control components (sensors, actuators, fuel flow components, etc.)

EVALUATION: determine control test facilities. Direct component and systems testing. Correlate test data. Evaluate test results. Make recommendations to design groups.

ANALYSIS: determine engine control parameters. Prepare systems. Block diagrams. Analyze controls stability. Provide performance specifications (systems and components).

RELOCATION EXPENSES PAID

Please write in strict confidence to:

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MACHINE DESIGN and DEVELOPMENT
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Are a few areas in which openings exist at Battelle for competent mechanical engineers. THESE POSITIONS ARE FOR ENGINEERS WHO DESIRE A PROFESSIONAL ENVIRONMENT, PROFESSIONAL OPPORTUNITIES TO GROW, and PROFESSIONAL ASSIGNMENTS. Our unusual educational program provides the opportunity for obtaining at no cost to the staff member an advanced degree at The OHIO STATE UNIVERSITY. BATTELLE'S BENEFIT PROGRAM includes FOUR WEEKS VACATION after only five years of employment.

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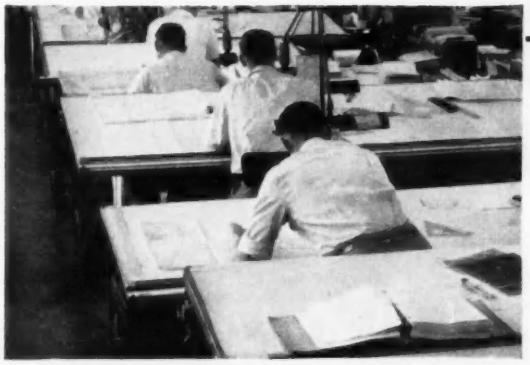
DESIGNER...MANUFACTURER...USER

here's why it'll pay you to specify

International® Power Units



DESIGNER

Your problems of engine power analysis, selection, and installation are simplified when you specify International power for your equipment. International's complete and experienced staff of manufacturer sales representatives, and sales and design engineers supply you with engine dimensional drawings, accurate power curves, and complete specifications. They also help you select the International engine best suited to your particular power, torque, and rpm requirements, and adapt International engines for your tough special applications.

MANUFACTURER

International engineering service can help you cut manufacturing costs, speed up production by showing you the best way to mount International engines in your equipment. Pilot engine models, for your research, production, and testing purposes are also available. In addition, you stand a better chance to sell more of your machines when you offer the buyer International engines as standard or optional equipment. Yes, International engines in the equipment you sell, helps you sell it faster...and helps keep it sold longer.

USER

When you specify International engines you gain the benefits of skill and experience of engine design and manufacture since 1903. In fact, more four-cycle, heavy-duty International diesel engines have been sold since production began in 1933 than any other make. Reasons for this terrific popularity are such inbuilt features as special delivery pressure lubrication through rifle-drilled passages, replaceable cylinder sleeves, and many others.

CHOOSE FROM 17 HEAVY-DUTY INTERNATIONAL DIESEL AND CARBURETED ENGINES—FROM 17 TO 214 HP.

See you at the
ROAD SHOW
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International Harvester Company
180 North Michigan Avenue, Chicago 1, Illinois

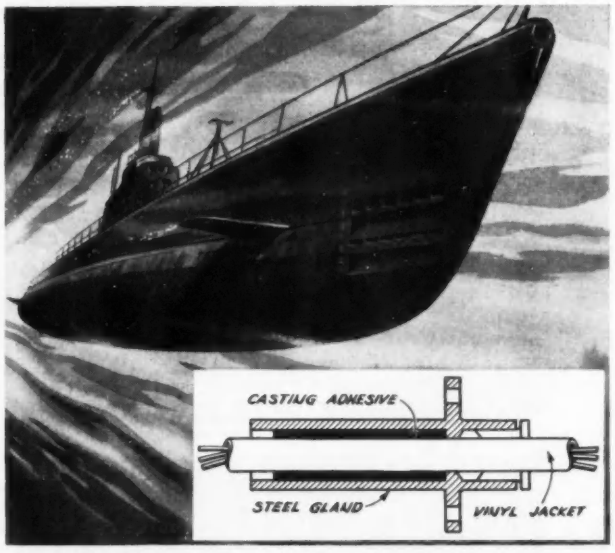
A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors... Self-Propelled Scrapers and Bottom-Dumps... Tractors and Rubber-Tired Loaders... Off-Highway Trucks... Diesel and Carbureted Engines... Motor Trucks.

R/M

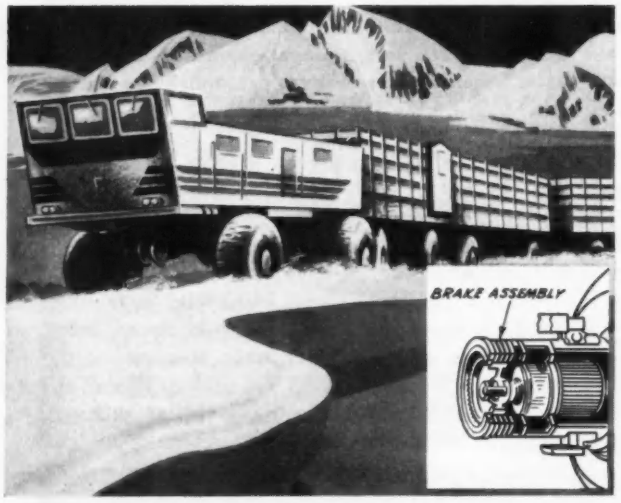
FIRST IN FRICTION

R/M ANNOUNCES OF ADHESIVES,

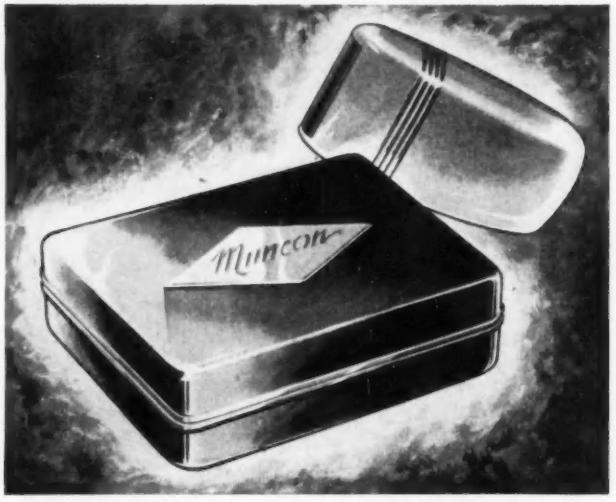
Polyethylene plastic presents a tough bonding problem. R/M helped overcome it in this farm irrigation pipe by recommending one of the new Ray-BOND adhesives to bond the fittings.



Ray-BOND adhesive bonds vinyl jacket and steel gland in this submarine cable—protecting against moisture and abrasion and improving dielectric properties.



This Snow Train travels across frozen Arctic wastes on 1200-mile treks carrying loads from 130 to 175 tons. To overcome low-temperature problems the brake linings are bonded with one of the new R/M adhesives.

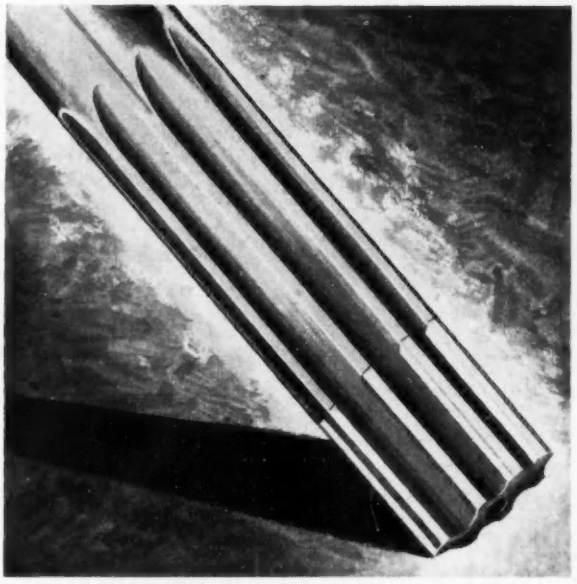


By using Ray-BOND adhesives to bond the metal name plate to the plastic case, an electric razor maker reduced personnel for this operation 75% —because of rapid adhesion and elimination of the pressing operation.

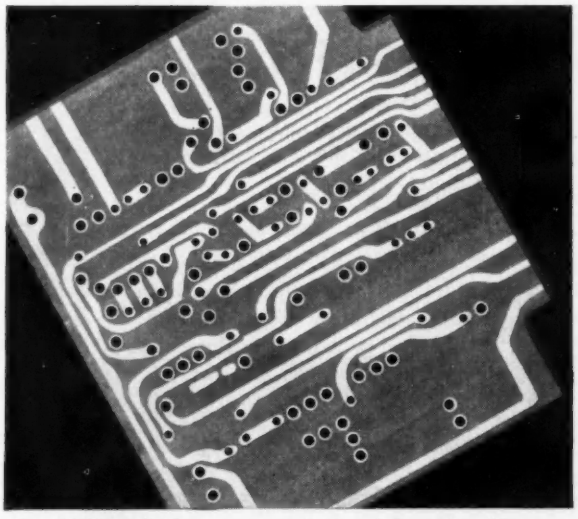
THE RECORD OF "FIRSTS" IN FRICTION MATERIAL DEVELOPMENT SHOWS WHY R/M IS FIRST IN FRICTION

FIRST Woven Brake Lining • FIRST Asbestos Brake Lining • FIRST Ground Wearing Surface • FIRST Zinc Alloy Wire Brake Lining • FIRST Pre-Treated Yarns • FIRST Extruded Pulp Brake Lining • FIRST Flexible Pulp Brake Lining in Rolls • FIRST Dry Process Brake Lining • FIRST Semi-Metallic Brake Lining • FIRST Bonded-to-Metal Brake Lining • FIRST Woven Clutch Facings • FIRST Molded Asbestos Clutch Facings for Clutches Operating in Oil FIRST Endless Woven Clutch Facings • FIRST Pre-Treated Clutch Facings • FIRST Bonded-to-Metal Clutch Facings

A SPECIALIZED LINE PROTECTIVE COATINGS AND SEALERS



The ceramic tip on this reamer is held strong and rigid by R/M Ray-BOND adhesives.



Ray-BOND adhesives overcome heat and flexural problems on printed circuits.

New Ray-BOND Products Cut Costs...Simplify Bonding for Wide Range of Materials and Applications

Adhesive bonding today is a well-established technique—with well-known advantages. It eliminates rivets and other fasteners—cuts production time and costs—provides better heat conductivity—increases life of friction members—seals gaps and voids in metal products. It often facilitates the fabrication of complex shapes. And with modern adhesives, it permits more effective bonding of dissimilar materials.

Ray-BOND thermosetting adhesives offer excellent bonding qualities and heat stability. Compounds are based on synthetic or natural rubber, resin bases of all types, and combinations of rubbers and resins which provide good performance under the most severe operating condition. Ability to resist temperature extremes ranging from -80° to as high as 700°F makes these adhesives very desirable for high-temperature applications. And where necessary, special formulations of these products can be devised for your specific needs.

If bonding, laminating, sealing or coating can cut costs or improve production in your own operations, contact Raybestos-Manhattan. With over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings, R/M has acquired a wealth of knowledge and experience that could help solve problems you may be facing now. Our engineers are ready to work closely with yours to make that solution prompt, practical and profitable for you.

Write now for your free copy of R/M Bulletin No. 650. It contains the engineering information you'll want to have on Ray-BOND Adhesives, Protective Coatings, Sealers.

R/M
FIRST IN FRICTION

THE TRADE-MARK THAT SPELLS PROGRESS IN FRICTION MATERIAL DEVELOPMENT

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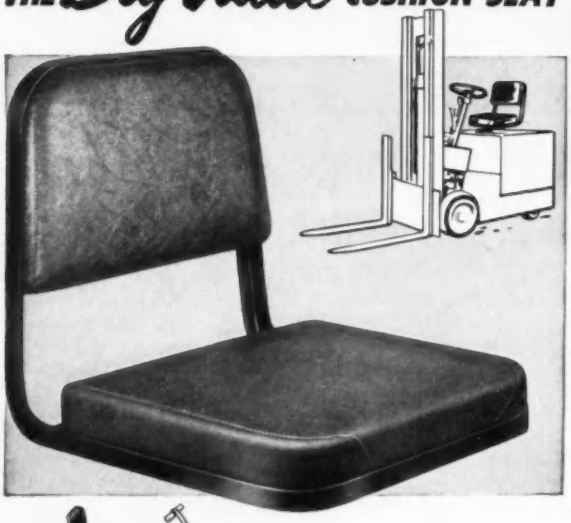
FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.
Raybestos-Manhattan (Canada) Limited, Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Industrial Rubber, Engineered Plastic & Sintered Metal Products • Rubber Covered Equipment • Asbestos Textiles • Laundry Pads & Covers • Packings • Abrasive & Diamond Wheels • Bowling Balls

CONTOUR
Milsco
MILWAUKEE
SEATING

Thrift-King

THE Big Value CUSHION SEAT



For POWER MOWERS, LIFT TRUCKS AND OTHER MEDIUM MOBILE EQUIPMENT

"Thrift-King" is a 2-way value seat for manufacturers of lift-trucks, mowers, and many types of medium mobile equipment: it definitely adds "sell;" it definitely improves workability. Full cushion foam rubber seat and full cushion foam rubber back rest assure sustained comfort and operational freedom. Wide choice of covering materials that will withstand outdoor use. Frame is of solid one-piece welded construction for rigorous service; easily attached. Available as illustrated, or with special features engineered to your equipment.

Write for complete information on America's finest line of cushion seating — Milsco.

MADE TO FIT YOUR NEEDS

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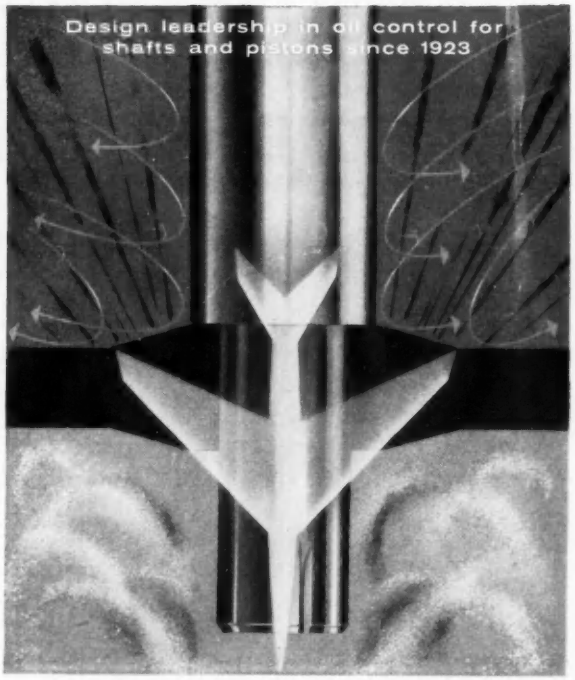
Specialists in Cushion Seating



Out-of-the ordinary

SHAFT SEAL PROBLEMS?

...solve them with SIMPLEX

High shaft speeds . . . high temperatures . . . special conditions . . . call for specialized help in designing suitable shaft seals.

As originators of the modern expansion ring sealing principle, SIMPLEX offers design help based on engineering leadership both in high-speed shaft seals and piston rings. SIMPLEX products are supplied as original equipment in Allison, Pratt & Whitney, Wright and other leading aircraft engines.

If your problems involve rings or seals, for jet or reciprocating aircraft engines or components, SIMPLEX can help you solve them. Call, wire or write.

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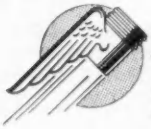

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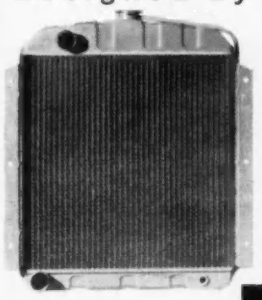

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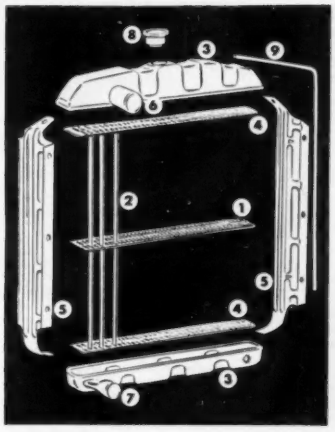

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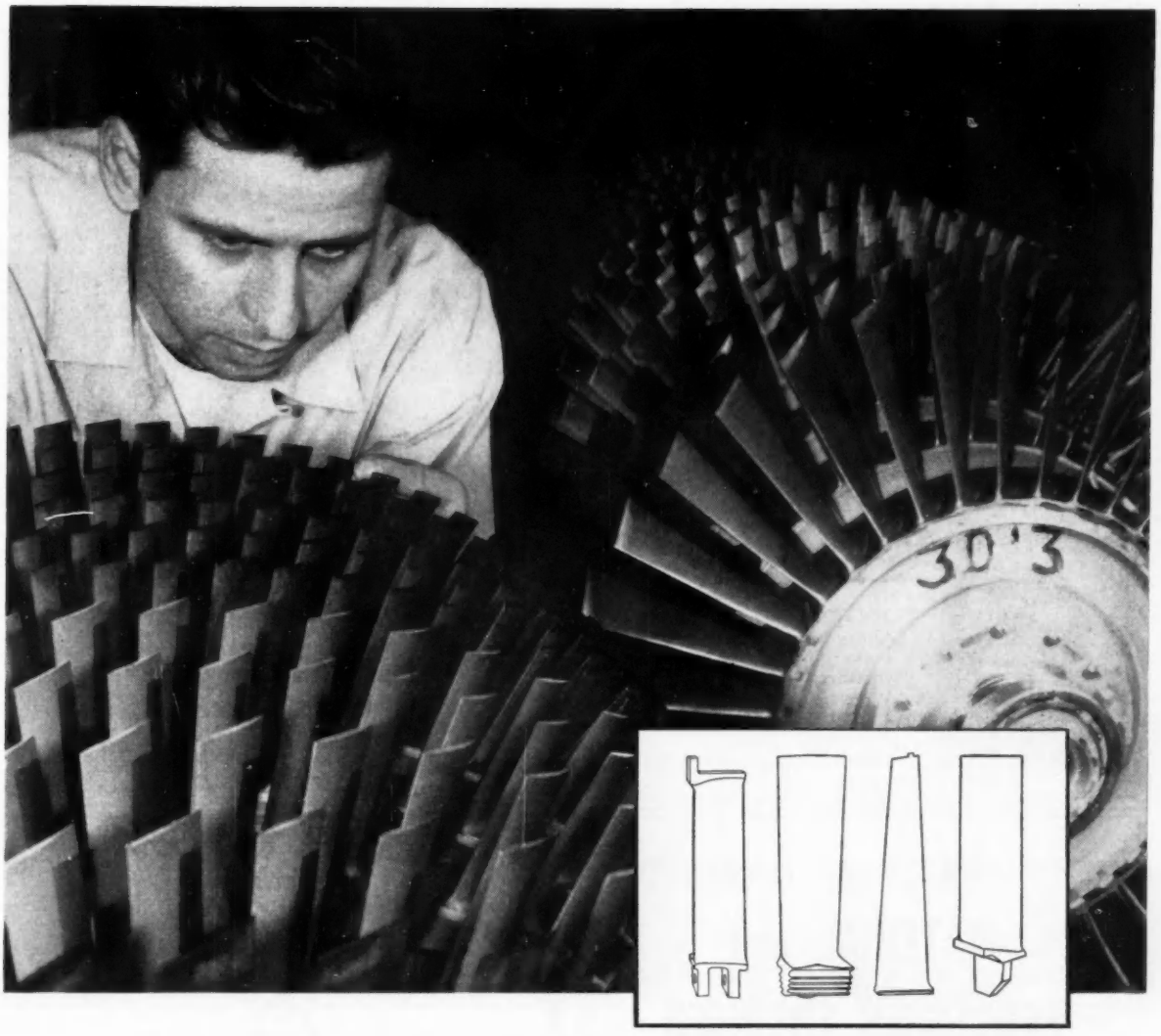

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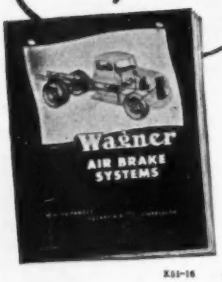

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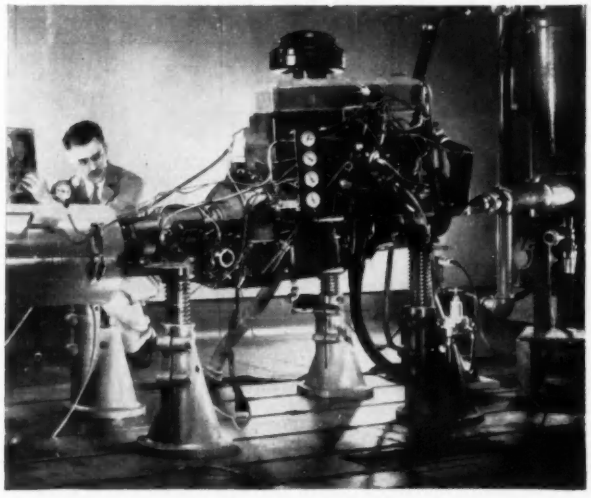

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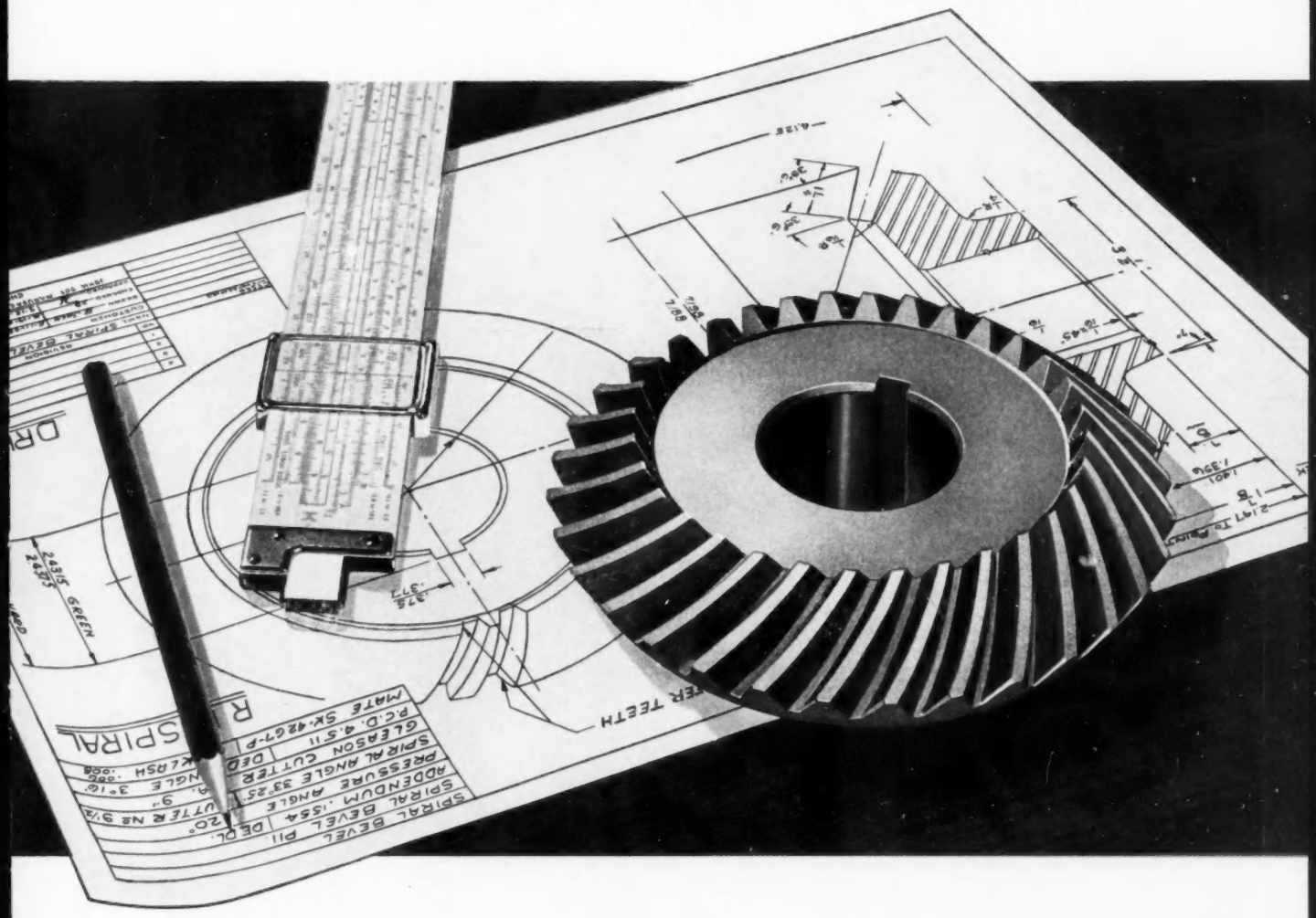

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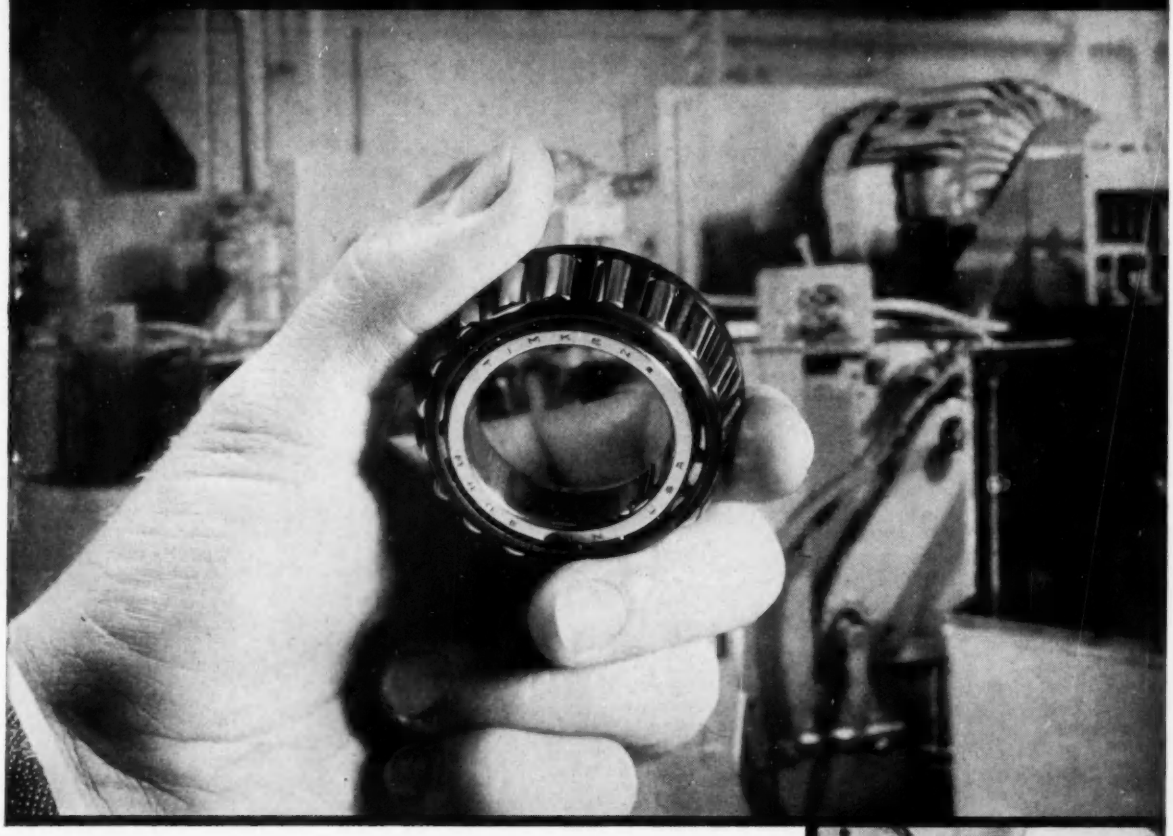

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